R&S®SMM-K114
OFDM Signal Generation
User Manual

1179195802
Version 08

ROHDE&SCHWARZ
Make ideas real

This document describes the following software options:

- R&S®SMM-K114 (1441.1824.xx)

This manual describes firmware version FW 5.30.047.xx and later of the R&S®SMM100A.

Muehldorfstr. 15, 81671 Muenchen, Germany
Phone: +49 89 41 29 - 0
Email: info@rohde-schwarz.com
Internet: www.rohde-schwarz.com

1179.1958.02 | Version 08 | R&S®SMM-K114

The following abbreviations are used throughout this manual: R&S®SMM100A is abbreviated as R&S SMM

Contents

1 Welcome to the OFDM Signal Generation option....................................7

1.1 Accessing the OFDM Signal Generation dialog....................................8

1.2 What's new....................................8

1.3 Documentation overview....................................8

1.3.1 Getting started manual....................................8

1.3.2 User manuals and help....................................8

1.3.3 Service manual....................................9

1.3.4 Instrument security procedures....................................9

1.3.5 Printed safety instructions....................................9

1.3.6 Data sheets and brochures....................................9

1.3.7 Release notes and open source acknowledgment (OSA)....................................10

1.3.8 Application notes, application cards, white papers, etc....................................10

1.3.9 Videos....................................10

1.4 Scope....................................11

1.5 Notes on screenshots....................................11

2 About OFDM Signal Generation option....................................12

2.1 Required options....................................12

2.2 Overview of modulation schemes....................................12

2.2.1 OFDM....................................12

2.2.2 f-OFDM....................................13

2.2.3 GFDM....................................13

2.2.4 UFMC....................................14

2.2.5 FBMC....................................15

2.2.6 Filtering....................................16

2.3 Supported multiple access schemes....................................21

2.4 Physical layer parameterization....................................24

2.5 Generating configuration files for R&S®VSE-K96....................................25

3 OFDM Signal Generation configuration and settings....................................27

3.1 General settings....................................27

3.2 General settings....................................30

3.2.1 Physical settings....................................30

3.2.2 Filter settings....................36
3.2.3 Modulation configuration settings....................39
3.3 Allocation settings....................41
3.3.1 User settings....................42
3.3.2 Allocations settings....................43
3.3.3 Split pattern settings....................48
3.3.4 SCMA settings....................49
3.3.5 Zadoff-Chu settings....................52
3.3.6 Constellation points settings....................53
3.3.7 Time plan....................54
3.4 Trigger settings....................55
3.5 Marker settings....................60
3.6 Clock settings....................62
3.7 Local and global connectors settings....................63

4 Remote-control commands....................64
4.1 General commands....................65
4.2 Physical commands....................68
4.3 Filter commands....................73
4.4 Modulation commands....................76
4.5 User commands....................77
4.6 Allocation commands....................79
4.6.1 General commands....................82
4.6.2 SCMA commands....................86
4.6.3 Split pattern commands....................89
4.6.4 Zadoff-Chu commands....................90
4.6.5 Custom constellation commands....................92
4.7 Trigger commands....................94
4.8 Marker commands....................100
4.9 Clock commands....................101

Annex....................102

A XML settings file....................102

Glossary: Terms and abbreviations....................105

Glossary: Specifications, references and further information...... 107

List of commands.. 108

Index.. 111

1 Welcome to the OFDM Signal Generation option

The R&S SMM100A-K114 is a firmware application that adds functionality to generate:

- User-defined OFDM signals
- Pre-release 5G signals in accordance with the 5GNOW project specification 5GNOW D3.x.

With the provided settings, you can generate any of the specified waveform types and parameterize the signals. For example, you can select the pulse-shaping filters, the subcarrier spacing and the number of carriers. Moreover, you can set the used modulation and data content and enable preamble and cyclic prefix generation. Configuration of the sparse code multiple access (SCMA) settings is supported, too.

The generated signal is suitable for testing of components or receivers with user-defined OFDM signals or realistic pre-5G physical layer signals.

The R&S SMM100A-K114 key features are:

- Support of GFDM, UFMC, FBMC, f-OFDM and OFDM waveforms
- Support of the proposed filter types
- Flexible resource allocation, independent of the frame-type structure
- Flexibly switching between different modulation formats, filters, symbol rates
- Support of multiple access schemes such as SCMA
- Optional use of a cyclic prefix or a preamble
- Internal signal generator solution, no need for external PC
- For f-OFDM and OFDM modulations, automatic generation of configuration file for upload in the R&S®VSE-K96.
- Optional discrete Fourier transformation spread OFDM (DFT-s-OFDM) for data allocations

This user manual contains a description of the functionality that the application provides, including remote control operation.

All functions not discussed in this manual are the same as in the base unit and are described in the R&S SMM100A user manual. The latest version is available at:

www.rohde-schwarz.com/manual/SMM100A

Installation

You can find detailed installation instructions in the delivery of the option or in the R&S SMM100A service manual.

1.1 Accessing the OFDM Signal Generation dialog

To open the dialog with OFDM Signal Generation settings

► In the block diagram of the R&S SMM100A, select "Baseband > OFDM Signal Generation".

A dialog box opens that displays the provided general settings.

The signal generation is not started immediately. To start signal generation with the default settings, select "State > On".

1.2 What's new

This manual describes firmware version FW 5.30.047.xx and later of the R&S®SMM100A.

Compared to the previous version, it provides the following new features:

- Cyclic suffix length for all modulation schemes, see "Cyclic Suffix Length" on page 35.
- DC subcarrier mode for all allocations, see "DC Mode" on page 35.
- Time-based triggering, see "Time Based Trigger" on page 57 and "Trigger Time" on page 57.
- Editorial changes

1.3 Documentation overview

This section provides an overview of the R&S SMM100A user documentation. Unless specified otherwise, you find the documents at:

www.rohde-schwarz.com/manual/smm100a

1.3.1 Getting started manual

Introduces the R&S SMM100A and describes how to set up and start working with the product. Includes basic operations, typical measurement examples, and general information, e.g. safety instructions, etc. A printed version is delivered with the instrument.

1.3.2 User manuals and help

Separate manuals for the base unit and the software options are provided for download:

- Base unit manual

Contains the description of all instrument modes and functions. It also provides an introduction to remote control, a complete description of the remote control commands with programming examples, and information on maintenance, instrument interfaces and error messages. Includes the contents of the getting started manual.

- Software option manual
  Contains the description of the specific functions of an option. Basic information on operating the R&S SMM100A is not included.

The contents of the user manuals are available as help in the R&S SMM100A. The help offers quick, context-sensitive access to the complete information for the base unit and the software options.

All user manuals are also available for download or for immediate display on the Internet.

1.3.3 Service manual

Describes the performance test for checking compliance with rated specifications, firmware update, troubleshooting, adjustments, installing options and maintenance.

The service manual is available for registered users on the global Rohde & Schwarz information system (GLORIS):

https://gloris.rohde-schwarz.com

1.3.4 Instrument security procedures

Deals with security issues when working with the R&S SMM100A in secure areas. It is available for download on the internet.

1.3.5 Printed safety instructions

Provides safety information in many languages. The printed document is delivered with the product.

1.3.6 Data sheets and brochures

The data sheet contains the technical specifications of the R&S SMM100A. It also lists the options and their order numbers and optional accessories.

The brochure provides an overview of the instrument and deals with the specific characteristics.

See www.rohde-schwarz.com/brochure-datasheet/smm100a

1.3.7 Release notes and open source acknowledgment (OSA)

The release notes list new features, improvements and known issues of the current firmware version, and describe the firmware installation.

The software makes use of several valuable open source software packages. An open-source acknowledgment document provides verbatim license texts of the used open source software.

See www.rohde-schwarz.com/firmware/smm100a

1.3.8 Application notes, application cards, white papers, etc.

These documents deal with special applications or background information on particular topics.

See www.rohde-schwarz.com/application/smm100a

1.3.9 Videos

Find various videos on Rohde & Schwarz products and test and measurement topics on YouTube: https://www.youtube.com/@RohdeundSchwarz

On the menu bar, search for your product to find related videos.

Figure 1-1: Product search on YouTube

1.4 Scope

Tasks (in manual or remote operation) that are also performed in the base unit in the same way are not described here.

In particular, it includes:

- Managing settings and data lists, like saving and loading settings, creating and accessing data lists, or accessing files in a particular directory.
- Information on regular trigger, marker and clock signals and filter settings, if appropriate.
- General instrument configuration, such as checking the system configuration, configuring networks and remote operation
- Using the common status registers

For a description of such tasks, see the R&S SMM100A user manual.

1.5 Notes on screenshots

When describing the functions of the product, we use sample screenshots. These screenshots are meant to illustrate as many as possible of the provided functions and possible interdependencies between parameters. The shown values may not represent realistic usage scenarios.

The screenshots usually show a fully equipped product, that is: with all options installed. Thus, some functions shown in the screenshots may not be available in your particular product configuration.

2 About OFDM Signal Generation option

The OFDM Signal Generation option enables you to create waveforms according to the following modulation schemes OFDM, f-OFDM, GFDM, UFMC and FBMC.

- Required options..12
- Overview of modulation schemes..12
- Supported multiple access schemes..21
- Physical layer parameterization...24
- Generating configuration files for R&S®VSE-K96..................................25

2.1 Required options

The basic equipment layout for generating OFDM signals includes the:

- Baseband Generator(R&S SMM-B9)
- Frequency option (e.g. R&S SMM-B1006)
- Baseband real-time extension (R&S SMM-K520)
- Digital standard OFDM Signal Generation (R&S SMM-K114)

You can generate signals via play-back of waveform files at the signal generator. To create the waveform file using R&S WinIQSIM2, you do not need a specific option.

To play back the waveform file at the signal generator, you have two options:

- Install the R&S WinIQSIM2 option of the digital standard, e.g. R&S SMM-K255 for playing LTE waveforms
- If supported, install the real-time option of the digital standard, e.g. R&S SMM-K55 for playing LTE waveforms

For more information, see data sheet.

2.2 Overview of modulation schemes

The section gives a brief overview of the techniques and methods.

2.2.1 OFDM

The OFDM modulation is similar to the f-OFDM modulation. Other as in the f-OFDM, the OFDM does not use subbands and there is no predefined filtering.

Related settings

- Chapter 3.2.1, "Physical settings", on page 30
- Chapter 3.2.3, "Modulation configuration settings", on page 39

2.2.2 f-OFDM

The filtered OFDM (f-OFDM) modulation is a technique similar to the UFMC modulation. Other as in the UFMC, in the f-OFDM uses frame-based filtering.

The method is also known as Spectrum Filtered-OFDM.

Related settings

- Chapter 3.2.1, "Physical settings", on page 30
- Chapter 3.2.2, "Filter settings", on page 36
- Chapter 3.2.3, "Modulation configuration settings", on page 39

2.2.3 GFDM

The Generalized Frequency Division Multiplexing (GFDM) is a method in which the data is processed on a two-dimensional block structure, both in time and in frequency domain. The GFDM waveform is a non-orthogonal, asynchronous multi-carrier waveform.

In GFDM, subcarriers are independent single carriers; they can have different bandwidth, pulse shape and modulation. Each subcarrier is shaped with an individual transmit filter and then modulated with the subcarrier center frequency. The modulation is performed on a per data block, where the data block size is a configurable value. The commonly used filters are the root-raised cosine filters.

The implementation principle is illustrated on Figure 2-1 ([1]).

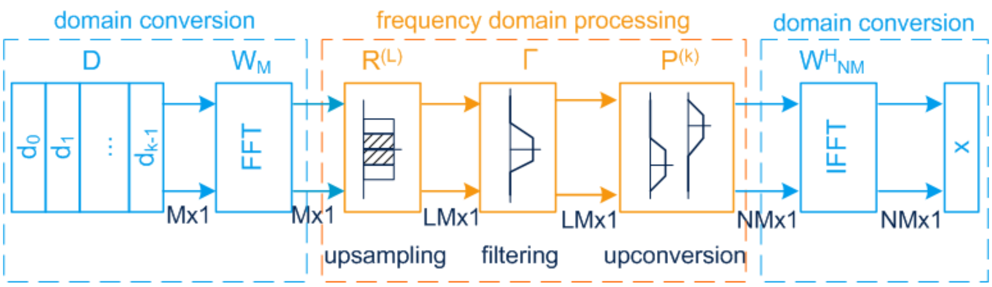


Figure 2-1: Optimized GFDM transmitter model (from [1])

D = Matrix of input symbols, QPSK, BPSK, or QAM modulated
d_k = Input vector
k = Number of active subcarrier
M = Number of symbols (block size).
N = FFT size
W_M = FFT matrix
$R^{(L)}$ = Upsampling matrix with upsampling factor L
Γ = Diagonal matrix containing the time samples of the filter pulse on its diagonal; the filtering is an element wise multiplication in the frequency domain.
$P^{(k)}$ = Permutation matrix that applies a frequency shift and moves the block input vectors to the position of the subcarriers.
W^H_{NM} = IFFT matrix that converts the signal from the frequency domain back to the time domain
x = $W^H_{NM}\Sigma_k P^{(k)}\Gamma R^{(L)} W_M d_k$

As shown in Figure 2-1, in GFDM a time-frequency response is divided into k subcarriers and M symbols.

Related settings

- Chapter 3.2.1, "Physical settings", on page 30
- Chapter 3.2.2, "Filter settings", on page 36
- Chapter 3.2.3, "Modulation configuration settings", on page 39

2.2.4 UFMC

The Universal Filtered Multi-carrier (UFMC) technique is similar to the known OFDM technique but the UFMC adds one extra filtering step in the signal processing chain.

In UFMC, several consecutive subcarries are bundled into subbands. All subbands have an equal size. Each subband is shaped with an individual Dolph-Chebyshev filter. The modulation uses an optional cyclic prefix for symbol separation.

Figure 2-2 ([2]) illustrates the system model of UFMC.

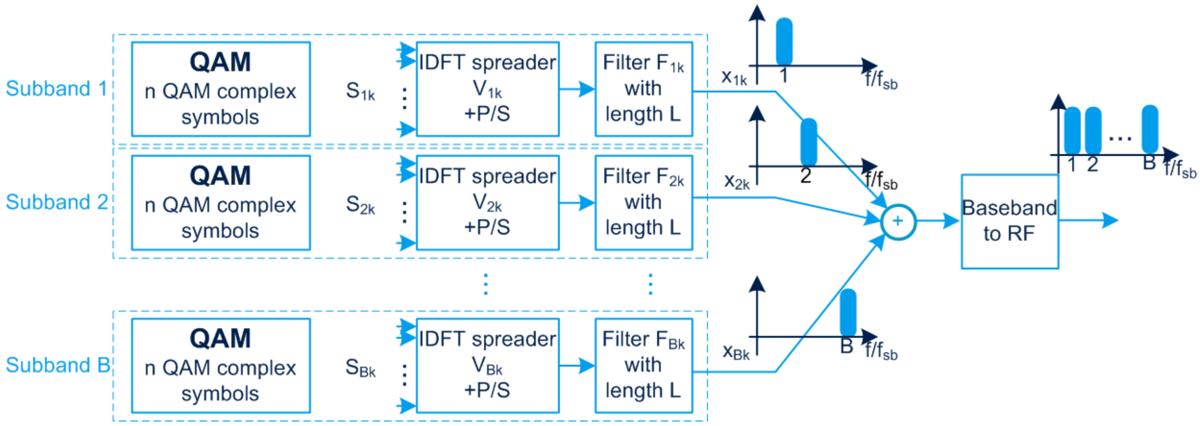


Figure 2-2: UFMC system model (from [2])

Subband = Group of consecutive subcarriers
B = Number of subbands
k = Number of active subcarriers
S_{Bk} = Vector of input symbols, QPSK, BPSK, or QAM modulated
IDFT = IFFT operation to transfer the n QAM symbols to the time domain
P/S = Parallel to serial conversion
F_{Bk} = Subband filters with filter length L
x_{Bk} = Output per subband; outputs are added.

The result is a UFMC waveform that is a non-orthogonal, asynchronous multi-carrier waveform.

Related settings

- Chapter 3.2.1, "Physical settings", on page 30
- Chapter 3.2.2, "Filter settings", on page 36
- Chapter 3.2.3, "Modulation configuration settings", on page 39

2.2.5 FBMC

In the Filter Bank Multi-Carrier (FBMC) system, the filtering is applied on a per subcarrier basis.

The FBMC uses a synthesis-analysis filter bank method. Different implementations of FBMC are discussed: Staggered modulated multitone (SMT FBMC), cosine modulated multitone (CMT FBMC), and filtered multitone (FMT FBMC). The main focus is on the SMT FBMC implementation.

In FBMS, adjacent subcarriers do overlap. The number of superimposing symbols in time is referred as overlapping factor K. To maintain the orthogonality between the adjacent subcarrier, the subcarriers are OQAM pre-processed. The cyclic prefix is optional.

The implementation principle is illustrated in Figure 2-3 ([3]).

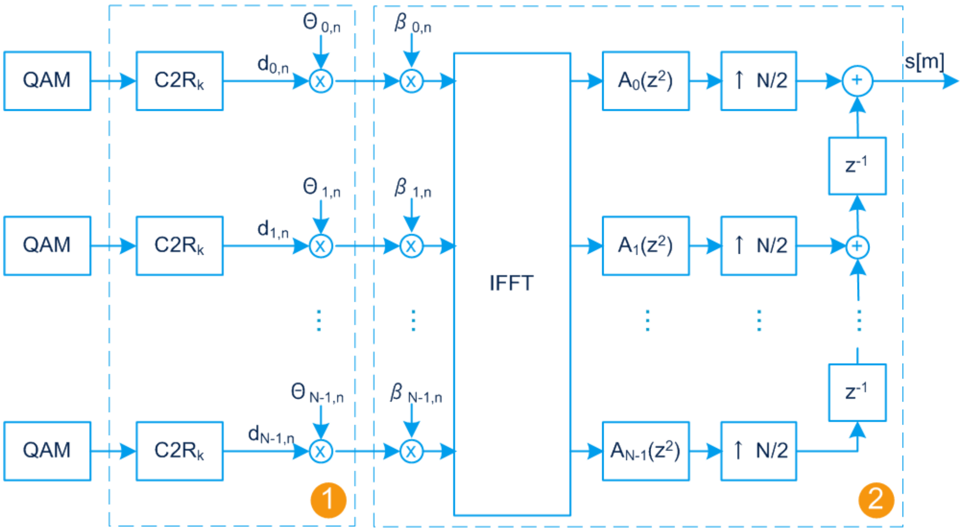


Figure 2-3: FBMC transmitter model (from [3])

1 = OQAM pre-processing (symbol staggering).
2 = Synthesis filter bank
N = Total number of subcarriers
k = 1,..., N is the subcarrier index
C2R = Complex to real conversion
⊗ = Complex multiplication by a factor Θ: Shifts the in-phase (I) components of the QAM symbols compared to the quadrature (Q) components
IFFT = Inverse fast Fourier transform
$A_k(z)$ = Polyphase filtering per subcarrier
N/2 = Upsampling by the factor N/2
Z^{-1} = Individual delays, added on each subcarrier
s[m] = Transmit signal (the sum of all subcarriers).
K = Overlapping factor; defines number of superimposing symbols in time.

OQAM pre-processing

Orthogonal QAM is method that shifts the in-phase components of the QAM modulated symbols by T/2 (a half of the symbol length) compared to the quadrature (Q) components. The shift is applied alternating between the subcarrier. For example, if in the subcarrier N-1 the I component is shifted, then in the neighbor subcarriers (N-2 and N) the Q component is shifted.

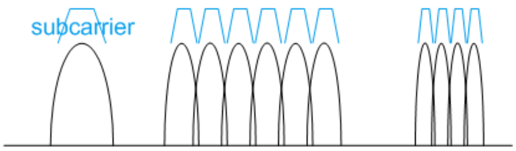
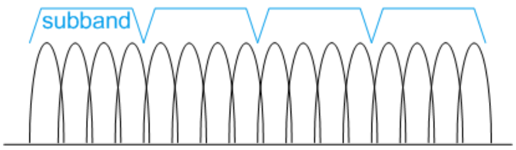
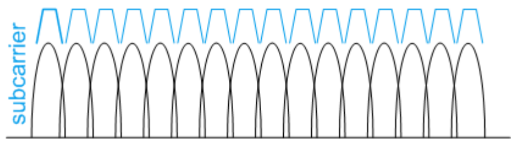
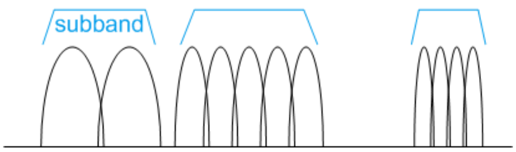
Related settings

- Chapter 3.2.1, "Physical settings", on page 30
- Chapter 3.2.2, "Filter settings", on page 36
- Chapter 3.2.3, "Modulation configuration settings", on page 39

2.2.6 Filtering

The modulation methods utilize filtering for signal shaping, but the filters are applied differently.

Table 2-1: Overview of time and frequency domain filtering per modulation method

Modulation methods	Time domain filtering	Frequency domain filtering
GFDM	Per frame	Per subcarrier 
UFMC	Per symbol	Per subband 
FBMC	Per K overlapping symbols (in this implementation, K = 4)	Per subcarrier 
f-OFDM	Per frame	Per subband 
OFDM	none	none

Each modulation method proposes a prototype filter with different characteristics, like filter type and filter length L. The proposed prototype filter types per modulation method are as follows:

- GFDM:
  Root cosine, root-raised cosine, Dirichlet, and rectangular filters
- UFMC:

Dolph-Chebyshev filter

- FBMC:
  Root-raised cosine, Phydyas filter
- f-OFDM:
  Soft truncation filter
- OFDM
  No default filter

For UFMC, f-OFDM and OFDM, you can also load a user-defined filter described in a file. See "User filter file format (*.dat files)" on page 19.

Proposed prototype filters

Prototype filters can be designed in several ways, where each approach aims to fully different requirements. In general, filters are designed to have good spectral characteristics and to be easy to be implemented.

GFDM relies on standard filter types with low complexity but with known drawback. A prototype filter with rectangular frequency response suffers from an infinitely long impulse response in time. A root-raised cosine filter improves the side lobe suppression.

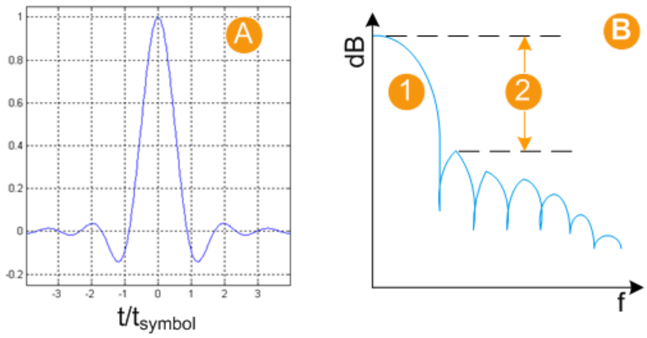


Figure 2-4: Example of filer characteristics: Root cosine filter with Roll Off Factor = 0.5

A = Filter impulse response
B = Filter frequency response
1 = Main lobe
2 = Side lobe suppression

Adjusting the filter parameters can change the filter shape. For example, changing the filter roll-off factor influences the steepness of the filter slopes.

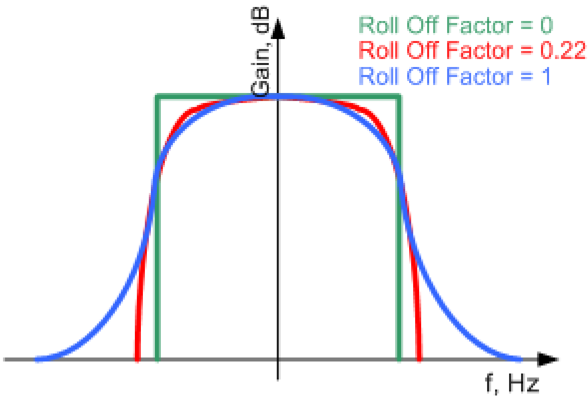


Figure 2-5: Example of the frequency response of a filter with different roll-off factors

In **f-OFDM**, the side lobe suppression is improved by applying a soft truncation window function. The modulation uses the commonly known Hamming and Hanning windowing functions. Optionally, the transient response of the filter is cut at the beginning and the end of the signal. The drawback of this operation is that it increases the out-of-band emissions.

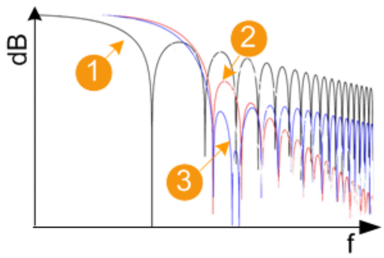


Figure 2-6: Effect of the windowing function

1 = Rectangular filter
2 = Hanning window
3 = Hamming window

As shown in Figure 2-6, the soft truncation improves the side lobe suppression but results in a wider main lobe.

UFMC proposes another windowing function with promising characteristics, the Dolph-Chebischev. The Dolph-Chebischev window is characterized by the filter length L in time domain and by the stopband attenuation (that is the desirable side lobe suppression) in the frequency domain.

In **FBMC**, the initial prototype filter is a root-raised cosine (RRC) filter with a roll-off factor of 1. The Phydyas project [3] proposes an extra prototype filter designed using frequency sampling technique. This prototype filter is described by a few filter coefficients that do not depend on the filter length.

For overlapping factor K = 4, the filter coefficients are [[3], 5GNOW D3.x]:

- $P_0 = 1$
- $P_1 = 0.97195981$
- $P_2 = 1/\sqrt{(2)}$

- $P_3 = \sqrt{(1 - P_1^2)}$

The filter time response is calculated as:

$$p_m = P_0 + 2\sum_{k=1}^{K-1} (-1)^k P_k \cos\left(\frac{2\pi k}{KN_c}(m+1)\right)$$

Figure 2-7: Phydyas filter: Time response calculation

m = 0 to $KN_c - 2$
K = 4 is the overlapping factor.
N = Number of subcarriers
n = Symbol number
T = Symbol period
k = Subcarrier number

The stopband attenuation of the Phydyas filter exceeds 60 dB for the frequency range of more than 10 subcarrier spacings [[3], 5GNOW D3.x].

User filter file format (*.dat files)

For UFMC, f-OFDM and OFDM, you can define your own filters in from user filter files. These files are ASCII files with simple format and file extension `*.dat`.

These files describe filters as a sequence of normalized filter coefficients. Each coefficient is defined as a pair of I and Q samples. The I and Q components alternate at each file line. The I and Q values vary between - 1 and + 1.

User filter file can contain up to 800 coefficients. Once loaded in the software, the file is evaluated and the parameter User Filter Length shows the number of coefficients.

You can create user filter files for example with MATLAB, see for example the following MATLAB script.

Example: Script that generates user filter file

```
Function [b, n] = generateUserFilter(filterSets, destPath)
% generateUserFilter returns the filter coefficients of a user-defined (baseband-)filter,
% whose are stored to a .dat file and can be
% loaded as an user filter in R&S SMW
%
% where:
% filterSets.fftSize is the used FFT size that is used for the OFDM modulation
% filterSets.nOccSubcarrier is the number of occupied subcarriers
% filterSets.transRegionRatio controls the steepness of the filter
% with regards to the ratio of fftSize/2
% filterSets.rp passband ripple in percentage
% filterSets.rs stopband attenuation ripple in percentage
%
% Example use:
% [b n] = RsFilt.generateUserFilter(struct('fftSize',4096, 'nOccSubcarrier',3376),'.');
%
% b - complex filter coefficients
% n - filter order


if (~isfield(filterSets,'transRegionRatio'))
    filterSets.transRegionRatio = 0.07;
end

if (~isfield(filterSets,'rp'))
    filterSets.rp = 0.0001;
end

if (~isfield(filterSets,'rs'))
    filterSets.rs = 60;
end

% steepness of filter
transRegion = filterSets.transRegionRatio * filterSets.fftSize/2; %in
%, controls steepness of filter slopes, relative to nyquist frequency

%cutoff frequencies
f = [filterSets.nOccSubcarrier/2 filterSets.nOccSubcarrier/2+transRegion];

%ripples in dB
dev = [(10^(filterSets.rp/20)-1)/(10^(filterSets.rp/20)+1) 10^(-filterSets.rs/20)];

%estimate filter order
[n,fo,ao,w] = firpmord(f,[1 0],dev,filterSets.fftSize);

%make filter symmetric
n = n + mod(n,2)

%generate filter coefficients
```

```
b = firpm(n,fo,ao,w);

% fvtool(b); %displays filter response

%% write filter out into .dat filter coefficient file
coeffsOut = zeros(2*length(b),1);
coeffsOut(1:2:end) = real(b); coeffsOut(2:2:end) = imag(b);
% serialize complex coefficients

if (exist('destPath'))
    dlmwrite([destPath '\smw_user_filter_' num2str(length(b))
    'taps_' num2str(filterSets.nOccSubcarrier)
    'scs_' num2str(filterSets.fftSize) 'fft.dat'],coeffsOut);
end

end
```

Related settings

- Chapter 3.2.2, "Filter settings", on page 36

2.3 Supported multiple access schemes

Multiple access schemes are offered to assign the individual allocations to different users.

Sparse Code Multiple Access (SCMA) is a non-orthogonal multiple access technology that is considered as a key candidate 5G multiple access scheme. This technique adds a CDMA (code division multiple access) component to the orthogonal division multiple access technology OFDMA. SCMA uses multi-layer sparse codewords to separate users that share common time and frequency resources.

In comparison to LTE, SCMA combines modulation mapping and spreading into one operation. Each layer corresponds to *unique* codebook. The binary input data are mapped directly to the multiple layers complex codeword and then spread over the subcarriers.

SCMA encoding and parameters dependency

The example in Figure 2-8 is an illustration of a codebook.

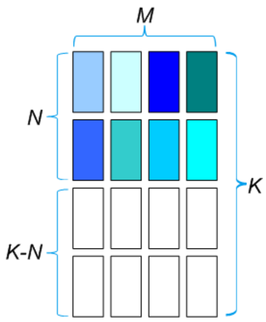


Figure 2-8: SCMA encoding parameters

M = 4 is the codebook size (that is the number of codewords)
K = 4 is the spreading factor (that is the spread codeword length)
N = 2 is the number of non-zero elements.
K-N = 2 is the number of zero elements.

The number of layers J (that is also the number of *unique* codebooks) is calculated as follows:

$$J = \binom{K}{N}$$

The number of layers gives the number of unique combinations that are possible for the given codeword length (K) and number of non-zero elements (N). For K = 4 and N = 2, the maximum number of layers is *J = 6*. In SCMA, one user can be assigned to several layers, whereas each layer can be assigned to exact one user. Hence, the maximum number of users corresponds to the number of layers and is also 6.

SCMA encoding parameterization

The SCMA implementation in R&S SMM-K114 is illustrated Figure 2-8. It uses the following fix parameters:

- Number of layers = 6
- Codebook size = 4
- Spreading factor = 4

The example in Figure 2-9 illustrates the principle of the SCMA encoding.

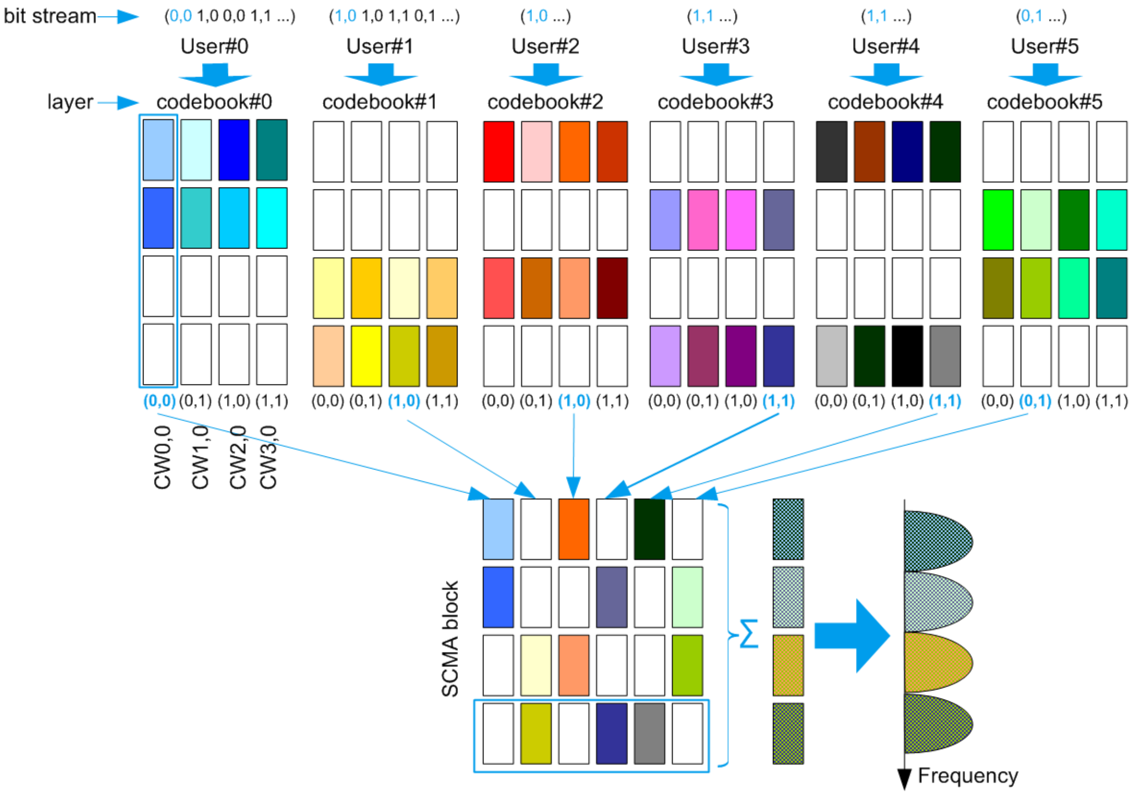


Figure 2-9: SCMA encoding example (K = 4, N = 2, J = 6)

User#x = 6 users
Codebook#x = 6 codebooks or layers
Bitstream = Binary input data per user, for example User#0 sends bits (0,0).
CWy,x = Codeword#y form codebook#x
∑ = Combining the symbols

In this example, each user is assigned to one layer (codebook). The bits that the users are transmitting are highlighted. For example, User#0 sends bits (0,0), that corresponds to codeword CW0,0 from the user-specific codebook#0. The 6 codewords of the 6 users are combined; note that max. 3 symbols overlap. The combined signal of 6 users is spread over the subcarriers; the spreading factor is 4.

Related settings

- Chapter 3.3.4, "SCMA settings", on page 49
- Chapter 3.3.2, "Allocations settings", on page 43

2.4 Physical layer parameterization

Data allocation and modulation

You can modulate input data symbols using modulation schemes:

- Base modulation with constellations: BPSK, QPSK, 16QAM, 64QAM, 256QAM, SCMA
- Custom modulated I/Q data from files containing other modulation schemes, like CAZAC sequences for instance. See "Custom I/Q file format (*.iqw or *.dat files)" on page 24.
- Zadoff-Chu sequence
- Custom constellation with individual constellation points

Related settings:

- "Constellation" on page 44
- Chapter 3.3.5, "Zadoff-Chu settings", on page 52
- Chapter 3.3.6, "Constellation points settings", on page 53

Custom I/Q file format (*.iqw or *.dat files)

Custom I/Q files are files in one of the following formats:

- ***.dat files**
  ASCII files with simple format and file extension `*.dat`.
  The file content is a sequence of pairs of I and Q samples. The I and Q components alternate at each file line. The I and Q values vary between - 1 and + 1.
- ***.iqw files**
  Binary files containing complex I/Q data of 32-bit floating point data type.
  The file contents are I/Q samples described as paired alternating I and Q values (IQIQIQ).

Related settings:

- "Data Source" on page 46

Cyclic prefix (CP)

A guard time called cyclic prefix (CP) can optionally be used. Note that the CP calculation depends on the used modulation scheme.

Related settings:

- "Cyclic Prefix Length" on page 32
- For f-OFDM, also:
  - "Alt. Cyclic Prefix Length" on page 33
  - "CP No. Symbols/Alt. CP No. Symbols" on page 34

Sequence length calculation

The sequence length depends on the modulation method. Sequence length can be expressed as number of symbols or as number of samples.

Calculation of the sequence length as number of **samples** and per modulation method is as follows:

- **f-OFDM/OFDM**
  Sequence Length [Samples] = ("Total Number of Subcarriers"*"Sequence Length" [Symbols] + "Cyclic Prefix Length"*"CP No. Symbols" + "Alt. Cyclic Prefix Length"*"Alt. CP No. Symbols")
- **UFMC**
  Sequence Length [Samples] = "Cyclic Prefix Length" + ("Total Number of Subcarriers" + "Filter Length" - 1)*("Sequence Length" [Symbols]
- **FBMC**
  – If "Cut Transient Response = Off":
    Sequence Length [Samples] = ("Sequence Length" [Symbols] + "Overlap Factor" - 0.5)*"Total Number of Subcarriers" + "Cyclic Prefix Length"
  – If "Cut Transient Response = On":
    Sequence Length [Samples] = ("Sequence Length" [Symbols] + "Overlap Factor" - 0.5)*"Total Number of Subcarriers" + "Cyclic Prefix Length" - "Total Number of Subcarriers"*"Overlap Factor"

  Where "Overlap Factor = 4"
- **GFDM**
  Sequence Length [Samples] = "Cyclic Prefix Length" + "Total Number of Subcarriers"*"Sequence Length" [Symbols]

2.5 Generating configuration files for R&S®VSE-K96

If you generate f-OFDM or OFDM modulated signals, the R&S SMM100A creates automatically an `*.xml` settings file. You can use this file for measurements with Rohde & Schwarz signal analyzer, for example R&S®VSE-K96.

R&S®VSE-K96 processes the waveforms, generated with R&S SMM100A, differently, depending on the allocation content:

- Pilots:
  For f-OFDM and OFDM, the R&S®VSE-K96 requires pilot allocations for the signal analysis. The analyzer needs the pilots to decode the channel coding properly.
- Data:
  The data allocations contain the resource elements of the corresponding modulation.
  If you use the generated `*.xml` settings file, the information on the pilots and data allocations is transmitted automatically.
- Reserved:
  Signal analyzer perceives reserved allocations as general OFDM modulated signals. The allocation content can be any user-defined information.

How to create, transfer and use the settings file

1. In the R&S SMM100A, configure the signal as required.

2. Enable signal generation ("State > On").

   The `*.xml` settings file is created automatically.
   It is saved in the user directory as `/var/user/K114/Exported_K114_settings_K96.xml`.

3. Connect to the user directory of the R&S SMM100A via USB, LAN, ftp or any other access methods.
   Open, for example, the `\\<R&S SMM100A IP Address>\share\K114\`.

4. Copy the `Exported_K114_settings_K96.xml` file

5. Transfer and load it in the R&S®VSE-K96

   Required settings are performed automatically, so that you can start analyzing the signal.

3 OFDM Signal Generation configuration and settings

Access:

► Select "Baseband" > "OFDM Signal Generation".

The remote commands required to define these settings are described in Chapter 3, "OFDM Signal Generation configuration and settings", on page 27.

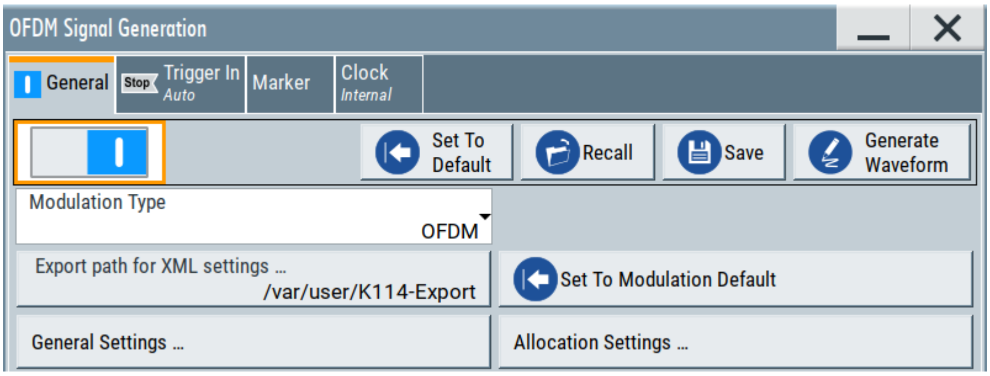
Settings:

- General settings...27
- General settings...30
- Allocation settings..41
- Trigger settings..55
- Marker settings...60
- Clock settings...62
- Local and global connectors settings..........................63

3.1 General settings

Access:

► Select "Baseband" > "OFDM Signal Generation" > "General".



This dialog comprises the standard general settings, to the default and the "Save/ Recall" settings, as well as selecting the modulation type and access to dialogs with further settings.

Settings:

State...28
Set to Default...28
Save/Recall...28

Generate Waveform File......28
Modulation Type......29
Export path for XML settings 29
Set to Modulation Default......30
General Settings 30
Allocation Settings 30

State

Activates the standard and deactivates all the other digital standards and digital modulation modes in the same path.

Remote command:
`[:SOURce<hw>]:BB:OFDM:STATe` on page 65

Set to Default

Calls the default settings. The values of the main parameters are listed in the following table.

Parameter	Values
State	Not affected by "Set to Default"
Modulation Type	OFDM

Remote command:
`[:SOURce<hw>]:BB:OFDM:PRESet` on page 66

Save/Recall

Accesses the "Save/Recall" dialog that is the standard instrument function for storing and recalling the complete dialog-related settings in a file. The provided navigation possibilities in the dialog are self-explanatory.

The filename and the directory, in which the settings are stored, are user-definable; the file extension is predefined.

See also, chapter "File and Data Management" in the R&S SMM100A user manual.

Remote command:
`[:SOURce<hw>]:BB:OFDM:SETTing:CATalog` on page 66
`[:SOURce<hw>]:BB:OFDM:SETTing:LOAD` on page 66
`[:SOURce<hw>]:BB:OFDM:SETTing:STORe` on page 66
`[:SOURce<hw>]:BB:OFDM:SETTing:DEL` on page 67

Generate Waveform File

With enabled signal generation, triggers the instrument to save the current settings of an arbitrary waveform signal in a waveform file with predefined extension `*.wv`. You can define the filename and the directory, in that you want to save the file.

Using the ARB modulation source, you can play back waveform files and/or process the file to generate multi-carrier or multi-segment signals.

Remote command:
`[:SOURce<hw>]:BB:OFDM:WAVeform:CREate` on page 67

Modulation Type
Selects the modulation type.

"OFDM"
You can create your own OFDM signal, for example configure the allocations as required.
For more information, see Chapter 2.5, "Generating configuration files for R&S®VSE-K96", on page 25.

"f-OFDM"
Filtered-OFDM
The filtered OFDM (f-OFDM) modulation is a technique similar to the UFMC modulation.
See Chapter 2.2.1, "OFDM", on page 12.
An *.xml setting file is created for this modulation type, too.
For more information, see Chapter 2.5, "Generating configuration files for R&S®VSE-K96", on page 25.

"UFMC"
Universal Filtered Multi-Carrier
UFMC is similar to OFDM but an additional filter is applied to each subband. The modulation used an optional cyclic prefix and a Dolph-Chebyshev filter.
See Chapter 2.2.4, "UFMC", on page 14.

"GFDM"
Generalized Frequency Division Multiplexing
Data processing is performed on a two-dimensional block structure, both in time and frequency domain.
Each subcarrier is pulse-shaped with a transmit filter and then modulated.
See Chapter 2.2.3, "GFDM", on page 13.

"FBMC"
Filter Bank Multi-Carrier
This modulation uses staggered modulated multitone filter bank (SMT FBMC) method where the subcarriers are OQAM modulated.
See Chapter 2.2.5, "FBMC", on page 15.

Remote command:
[:SOURce<hw>]:BB:OFDM:MODulation on page 67

Export path for XML settings ...
Accesses a standard "File Select" dialog to specify the output path of the created *.xml settings file.

By default, the output path `/var/user/K114-Export` and output file `Exported_K114_settings_K96.xml` are specified.

If modulation is active ("State" > "On"), the `*.xml` settings file is created automatically. You can use this file for measurements with Rohde & Schwarz signal analyzer, for example R&S®VSE-K96.

See also Example"Default "Exported_K114_settings_K96.xml" file" on page 102.

Remote command:
`[:SOURce<hw>]:BB:OFDM:OUTPath` on page 67

Set to Modulation Default
Calls the default settings for the selected Modulation Type.

Remote command:
`[:SOURce<hw>]:BB:OFDM:MODPreset` on page 67

General Settings ...
Accesses the "General Settings" dialog of the selected modulation.

For description, see:
- Chapter 3.2.1, "Physical settings", on page 30
- Chapter 3.2.2, "Filter settings", on page 36
- Chapter 3.2.3, "Modulation configuration settings", on page 39

Remote command:
n.a.

Allocation Settings ...
Accesses the "Allocation Settings" dialog, see Chapter 3.3, "Allocation settings", on page 41.

Remote command:
n.a.

3.2 General settings

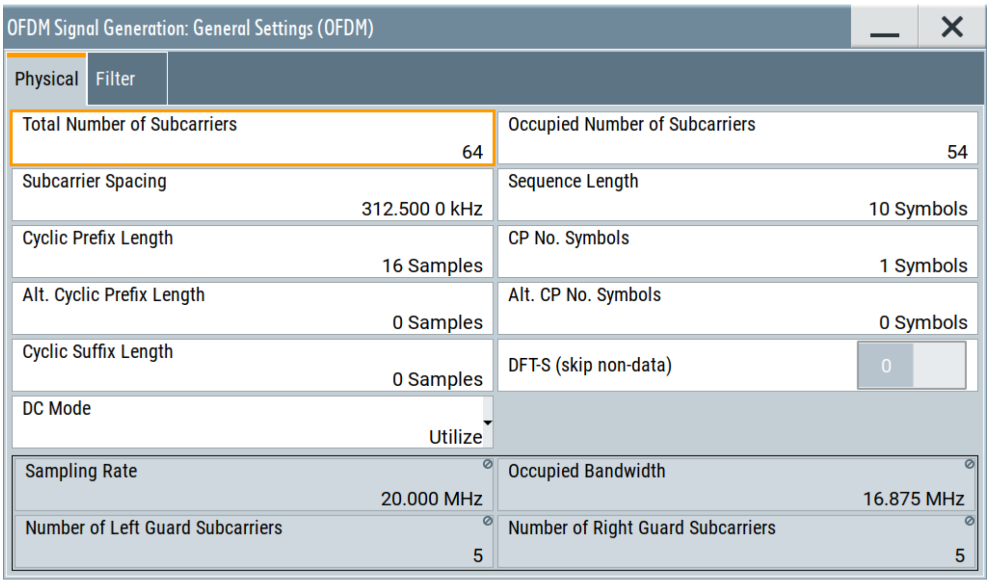
- Physical settings....................................30
- Filter settings....................................36
- Modulation configuration settings....................................39

3.2.1 Physical settings

Access:

► Select "OFDM Signal Generation" > "General Settings".

The physical settings are common to all modulation schemes.



Settings:

Total Number Of Subcarriers....31
Occupied Number of Subcarriers....31
Subcarrier Spacing....32
Sequence Length....32
Cyclic Prefix Length....32
Alt. Cyclic Prefix Length....33
CP No. Symbols/Alt. CP No. Symbols....34
Cyclic Suffix Length....35
DFT-S (skip non-data)....35
DC Mode....35
Sampling Rate....35
Occupied Bandwidth....36
Number Of Left/Right Guard Subcarriers....36

Total Number Of Subcarriers

Sets the number of available subcarriers that is the FFT size.

The maximum number of subcarriers depends on the selected "Subcarrier Spacing" as follows:

"Total Number of Subcarriers" * Subcarrier Spacing ≤ Bandwidth_{max}

The available baseband bandwidth depends on the installed options, see data sheet.

See also Chapter 2.4, "Physical layer parameterization", on page 24 for an overview of this cross-reference between the parameters.

Remote command:

`[:SOURce<hw>]:BB:OFDM:NSUBcarriers` on page 68

Occupied Number of Subcarriers

Sets the number of occupied subcarriers.

The maximum number of occupied subcarriers is calculated as follows:

"Occupied Number of Subcarriers"$_{max}$ = 0.83 * Total Number Of Subcarriers

For the UFMC modulation, the "Occupied Number of Subcarriers" has to be a multiple of the selected Number of Subbands.

See also Chapter 2.4, "Physical layer parameterization", on page 24 for an overview of this cross-reference between the parameters.

Remote command:
`[:SOURce<hw>]:BB:OFDM:NOCCupied` on page 69

Subcarrier Spacing
Sets the frequency distance between the carrier frequencies of the subcarriers.

The subcarriers are evenly distributed within the available bandwidth. All subcarriers span the same bandwidth and there is no frequency gap between adjacent subcarriers. Hence, the parameter "Subcarrier Spacing" sets also the subcarrier bandwidth.

See also Chapter 2.4, "Physical layer parameterization", on page 24 for an overview of this cross-reference between the parameters.

Remote command:
`[:SOURce<hw>]:BB:OFDM:SCSPace` on page 69

Sequence Length
Sets the sequence length of the signal in number of symbols.

See also "Sequence length calculation" on page 24.

Remote command:
`[:SOURce<hw>]:BB:OFDM:SEQLength` on page 69

Cyclic Prefix Length
Sets the cyclic prefix (CP) length as number of samples.

The maximum value equals the total number of subcarriers, see "Total Number Of Subcarriers" on page 31. The maximum number of symbols that can be used as a CP is calculated as follows:

"Cyclic Prefix Length"$_{max}$ = 0.5*Total Number Of Subcarriers

The cyclic prefix calculation depends on the modulation scheme:
- **f-OFDM/OFDM**
  Similar to the calculation in LTE, the cyclic prefix is applied as a *cyclic extension to each symbol*.

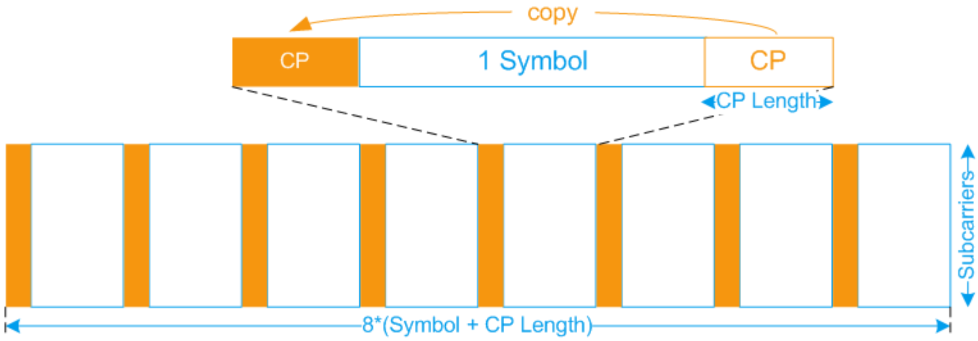


Figure 3-1: Principle of cyclic prefix calculation in f-OFDM/OFDM (default configuration with CP No. Symbols = 0, Alt. Cyclic Prefix Length = 0)

CP	=	Cyclic prefix
CP Length	=	Selected number of samples
Subcarriers	=	Total Number Of Subcarriers
Sequence Length	=	Selected number of symbols; 8 symbols in this example
Total number of samples	=	Calculated as described in "Sequence length calculation" on page 24

To apply different CP to a certain number of symbols or to use an alternating CP pattern, use the combination of the parameters Alt. Cyclic Prefix Length and CP No. Symbols/Alt. CP No. Symbols.

- **UFMC, GFDM, FBMC**
  If a "CP Length ≠ 0" is selected, then last samples of the complete signal are pre-pended to the signal.

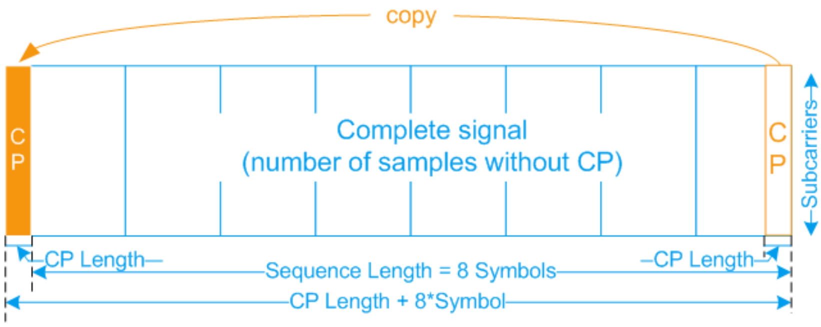


Figure 3-2: Principle of cyclic prefix calculation in UFMC, GFDM, and FBMC

CP	=	Cyclic prefix
CP Length	=	Selected number of samples
Subcarriers	=	Total Number Of Subcarriers
Sequence Length	=	Selected number of symbols; 8 symbols in this example
Total number of samples	=	Calculated as described in "Sequence length calculation" on page 24

Remote command:
`[:SOURce<hw>]:BB:OFDM:CPLength` on page 69

Alt. Cyclic Prefix Length
For f-OFDM/OFDM, you can modify the default CP assignment where the same CP is applied to each symbol and enable additional alternative CP, see Figure 3-3.

Both cyclic prefix (CP) lengths are set as number of samples. The parameters CP No. Symbols/Alt. CP No. Symbols determine for how many symbols each of the CP is applied. These parameters thus define a pattern of alternating cyclic prefixes.

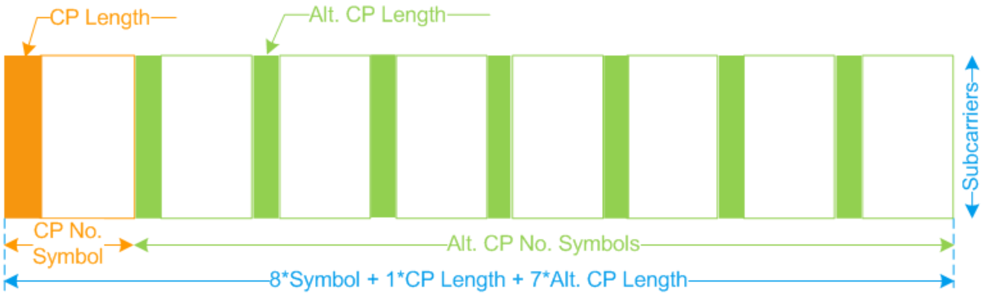


Figure 3-3: Dynamic cyclic prefixes in f-OFDM/OFDM (example with Alt. Cyclic Prefix Length ≠ Cyclic Prefix Length, CP No. Symbols = 1, Alt. CP No. Symbols = 7)

CP	= Cyclic prefix
CP Length	= CP duration as number of samples, e.g 160 samples
Alt. CP Length	= Duration of the alternative CP as number of samples, e.g 144 samples
CP No. Symbol	= 1 (number of symbols for that the selected CP length is applied).
Alt. CP No. Symbols	= 7 (number of symbols for that the selected Alt. CP length is applied).
Sequence Length	= Selected number of symbols; 8 symbols in this example
Subcarriers	= Occupied Number of Subcarriers, e.g. 400 so that the Occupied Bandwidth = 20 MHz
Total number of samples	= Calculated as described in "Sequence length calculation" on page 24

Remote command:
`[:SOURce<hw>]:BB:OFDM:ACPLength` on page 70

CP No. Symbols/Alt. CP No. Symbols
For f-OFDM/OFDM, these parameters determine for how many symbols each of the CP (Cyclic Prefix Length and Alt. Cyclic Prefix Length) is applied.

See also Figure 3-3.

0 Disables the corresponding CP.
Thus, even if a CP length different than zero is set but an alternative CP length with "Alt. CP No. Symbols ≠ 0" is configured, the CP length is ignored, if "CP No. Symbols = 0". The alternative CP length is applied or all symbols in the sequence.

Example:

If:
- "Sequence Length = 8"
- "Cyclic Prefix Length = 160" and "CP No. Symbols = 0"
- "Alt. Cyclic Prefix Length = 144" and "Alt. CP No. Symbols = 2"

Then a CP of 144 samples is applied to all 8 symbols.

Other than 0 — The value ranges of the parameters are calculated as follows:
"CP No. Symbols" + "Alt. CP No. Symbols" ≤ "Sequence Length"
If the sum is shorter than the "Sequence Length", the defined CP pattern is applied cyclically within this sequence length. Unused CP length values are discarded.

Example:

If:
- "Sequence Length = 8"
- "Cyclic Prefix Length = 160" and "CP No. Symbols = 2"
- "Alt. Cyclic Prefix Length = 144" and "Alt. CP No. Symbols = 3"

Then the CP = 160 samples is applied to symbols 1, 2, 6 and 7 and the CP = 144 samples - to symbols 3, 4, 5 and 8.

Remote command:
[:SOURce<hw>]:BB:OFDM:CPSYmbols on page 70
[:SOURce<hw>]:BB:OFDM:ACPSymbols on page 70

Cyclic Suffix Length
Sets the cyclic suffix length in samples. The maximum value equals the total number of subcarriers, see "Total Number Of Subcarriers" on page 31.

Remote command:
[:SOURce<hw>]:BB:OFDM:CSLength on page 71

DFT-S (skip non-data)
Activates discrete Fourier transform spread OFDM (DFT-s-OFDM) uplink scheme. Use this precoding setting to reduce crest factors of generated OFDM signals that contain data allocations.

If activated, applies a DFT on all data allocations. These allocations use "Content Type" > "Data", see "Content Type" on page 47. All non-data allocations are added after DFT, for example, when mapping the pilots.

Remote command:
[:SOURce<hw>]:BB:OFDM:DFTS:STATe on page 71

DC Mode
Sets the DC subcarrier mode.

"Utilize" — Uses the DC subcarrier for all allocations.

"Puncture" — Replaces the DC subcarrier by zeroes for all allocations.

"Skip" — Skips the DC subcarrier in the discrete Fourier transformation (DFT).
You cannot activate "DFT-S (skip non-data)", see "DFT-S (skip non-data)" on page 35.
The LTE standard, for example, uses this skipping method.

Remote command:
[:SOURce<hw>]:BB:OFDM:DCMode on page 71

Sampling Rate
Displays the sampling rate.

The value is derived as follows:

"Sampling Rate" = Total Number Of Subcarriers * Subcarrier Spacing

Remote command:
[:SOURce<hw>]:BB:OFDM:SAMPling? on page 71

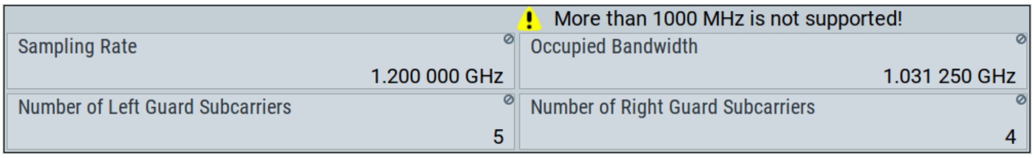
Occupied Bandwidth
Displays the occupied bandwidth.

The value is derived as follows:

"Occupied Bandwidth" = Occupied Number of Subcarriers * Subcarrier Spacing

Some settings result in a higher "Occupied Bandwidth" than the maximum bandwidth of the R&S SMM100A. If the maximum bandwidth is exceeded, a warning message indicates the maximum supported bandwidth given the installed hardware options.

The figure below shows an example of the R&S SMM100A equipped with maximum bandwidth of 1000 MHz (R&S SMM-K522). "Occupied Number of Subcarriers > 55" and "Subcarrier Spacing = 18.75 MHz" result in "Occupied Bandwidth = 1.03125 MHz". The warning message displays the supported maximum bandwidth.



Remote command:
[:SOURce<hw>]:BB:OFDM:BWOCcupied? on page 72

Number Of Left/Right Guard Subcarriers
Displays the number of left guard and right guard subcarriers.

The number of guard subcarriers is calculated as follows:
- "Number Of Left Guard Subcarriers" is the rounded up value of (Total Number Of Subcarriers - Occupied Number of Subcarriers) / 2
- "Number Of Right Guard Subcarriers" = Total Number Of Subcarriers - "Number Of Left Guard Subcarriers"

Remote command:
[:SOURce<hw>]:BB:OFDM:LGUard? on page 72
[:SOURce<hw>]:BB:OFDM:RGUard? on page 72

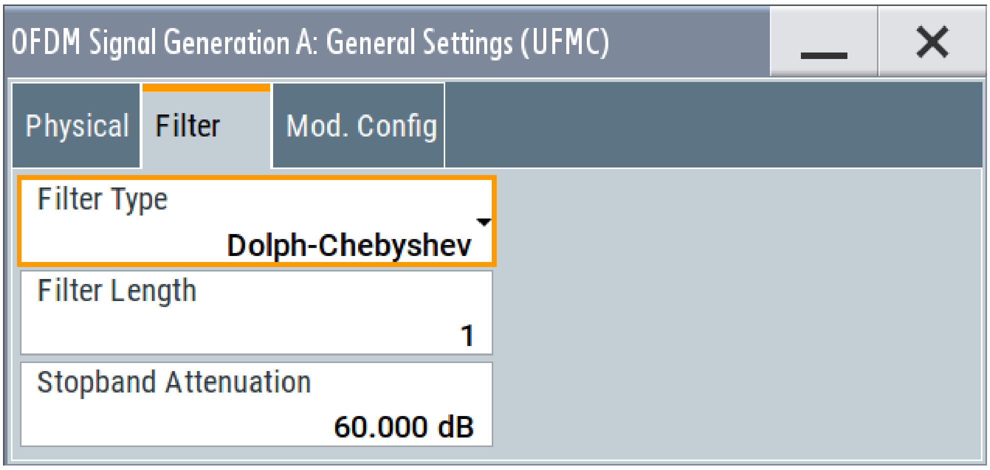
3.2.2 Filter settings

Access:

1. Select "OFDM Signal Generation" > "General".
2. Select the modulation type.
   Select, for example, "Modulation Type" > "UFMC".
3. Select "General Settings".

4. Select "Filter".

   This tab provides settings to configure filters. The filter settings depend on the selected modulation scheme.



   See also Chapter 2.2.6, "Filtering", on page 16.

Settings:

Filter Type 37
Rolloff Factor 38
Filter Length 38
Stopband Attenuation 38
Windowing Method 38
Cut Transient Response 39
User Filter Length 39
Load User Filter 39

Filter Type

Sets the filter type.

The available types depend on the selected "Modulation Type":

- "OFDM":
  None
- "f-OFDM":
  Soft truncation filter
- "GFDM":
  Root cosine filter, root raised cosine filter, Dirichlet filter and rectangular filter
- "UFMC":
  Dolph-Chebyshev filter
- "FBMC":
  Root raised cosine filter, Phydyas filter

Also, you can load a user-defined filter described in a file.

See also Chapter 2.2.6, "Filtering", on page 16.

Remote command:

`[:SOURce<hw>]:BB:OFDM:FILTer:TYPE` on page 73

Rolloff Factor
Sets the filter parameter.

The rolloff factor affects the steepness of the filter slopes. A "Rolloff Factor = 0" results in the steepest slopes; values near to 1 make the slopes more flat.

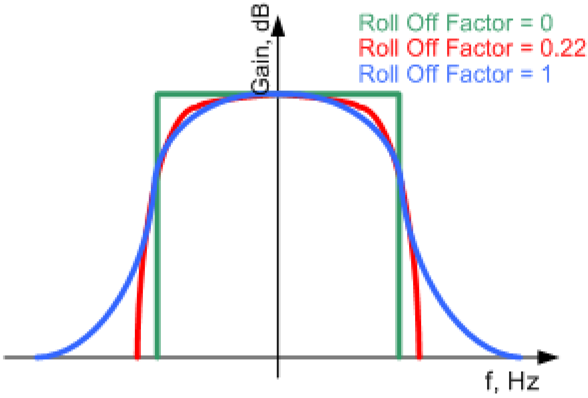


Figure 3-4: Example of the frequency response of a filter with different rolloff factors

Remote command:
[:SOURce<hw>]:BB:OFDM:FILTer:ROLLoff on page 74

Filter Length
Set the number of filter tabs and changes the filter shape in the time domain.

Remote command:
[:SOURce<hw>]:BB:OFDM:FILTer:LENGth on page 74

Stopband Attenuation
The UFMC modulation uses a Dolph-Chebyshev window to filter each subband.

The following parameters affect the shape of the Dolph-Chebyshev window:
- Filter Length (L) changes the shape in the time domain
- "Stopband Attenuation" or sidelobe attenuation affects the shape in the frequency domain.

See also "Proposed prototype filters" on page 17.

Remote command:
[:SOURce<hw>]:BB:OFDM:FILTer:SBATtenuation on page 74

Windowing Method
The f-OFDM modulation uses a soft truncation window to filter each subband.

The windowing model affects the shape in the frequency domain. The Hamming windowing method, for example, is optimized for better side-lobes suppression.

The following parameters also affect the shape of the filter window:
- Filter Length
- Cut Transient Response

See also "Proposed prototype filters" on page 17.

Remote command:
[:SOURce<hw>]:BB:OFDM:FILTer:WINDowing on page 75

Cut Transient Response
Cuts the transient response of the filtering operation at the beginning and end of the signal. The length of the cut samples depends on the selected Filter Length.

See also "Proposed prototype filters" on page 17.

Remote command:
`[:SOURce<hw>]:BB:OFDM:FILTer:CUTTrans` on page 74

User Filter Length
Indicates the number of filter coefficients in the user filter file, see "User filter file format (*.dat files)" on page 19.

Remote command:
`[:SOURce<hw>]:BB:OFDM:FILTer:ULENgth?` on page 75

Load User Filter
Accesses the dialog "Select List File User Filter" for loading a user-defined filter file.

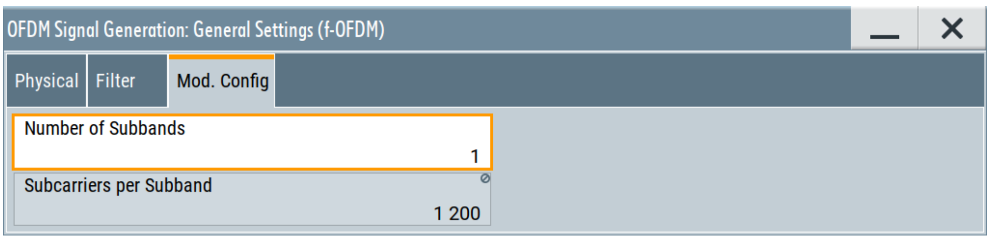
User filters are described in files with extension `*.dat`, see "User filter file format (*.dat files)" on page 19.

Remote command:
`[:SOURce<hw>]:BB:OFDM:FILTer:USELection` on page 75
`[:SOURce<hw>]:BB:OFDM:FILTer:UCATalog?` on page 75

3.2.3 Modulation configuration settings

Access:

1. Select "OFDM Signal Generation" > "General".
2. Select the modulation type.
   Select, for example, "Modulation Type" > "UFMC".
3. Select "General Settings".
4. Select "Mod. Config".



This tab provides settings to configure the modulation for modulation types "f-OFDM", "UFMC", "FBMC" and "GFDM". The provided settings depend on the selected modulation type.

Settings:

Number of Subbands.. 40
Subcarriers per Subband.. 40
Subband Filter Pre-equalization...40
Datablock Size.. 41
Overlap Factor... 41

Number of Subbands

Requires "Modulation Type" > "f-OFDM"/"UFMC".

Sets the number of subbands. A subband is a group of adjacent subcarriers. The number of subcarriers in one subband is calculated as follows:

Subcarriers per Subband = Occupied Number of Subcarriers / Number of Subbands

Remote command:
`[:SOURce<hw>]:BB:OFDM:UFMC:NSUBand` on page 77
`[:SOURce<hw>]:BB:OFDM:FOFDm:NSUBand` on page 76

Subcarriers per Subband

Requires "Modulation Type" > "f-OFDM"/"UFMC".

Indicates the number of adjacent subcarriers within a subband. This number calculated as follows:

Subcarriers per Subband = Occupied Number of Subcarriers / Number of Subbands

Remote command:
`[:SOURce<hw>]:BB:OFDM:SUBCarriers?` on page 76

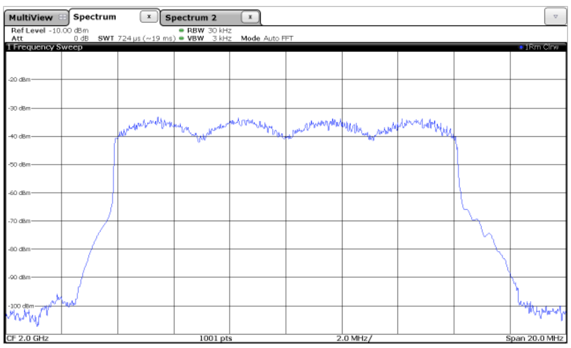
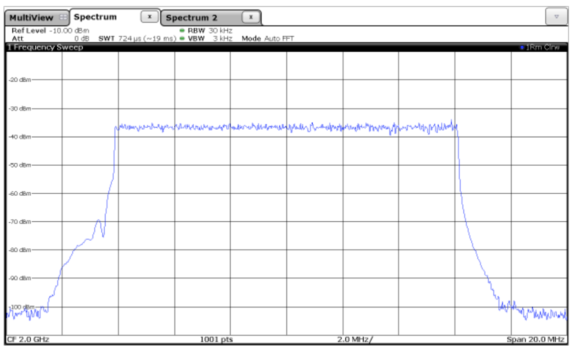
Subband Filter Pre-equalization

Requires "Modulation Type" > "UFMC".

Applies a filter pre-equalization according to the specification 5GNOW D3.x.

It equalizes the non-ideal filter response of the subband filter by increasing or decreasing the power of outer and inner subcarriers of a subband.

Table 3-1: Effect of filter pre-equaölization on the UFMC modulation (Number of Subbands = 4)

"Subband Filter Pre-equalization" > "Off"	"Subband Filter Pre-equalization" > "On"
	

Remote command:
`[:SOURce<hw>]:BB:OFDM:UFMC:PREequal` on page 77

Datablock Size
Requires "Modulation Type" > "GFDM".

Sets data block size M in terms of symbols per data block.

The "Datablock Size" is a value between 1 and the Sequence Length value and must be a common divisor of the "Sequence Length".

Remote command:
`[:SOURce<hw>]:BB:OFDM:GFDM:DBSYmbols` on page 76

Overlap Factor
Requires "Modulation Type" > "FBMC".

Describes the number of overlapping (superimposed) symbols in time on the same subcarrier.

This parameter influences the filter length.

Remote command:
n.a.

3.3 Allocation settings

Access:

1. Select "OFDM Signal Generation" > "General".
2. Select the modulation type.
   Select, for example, "Modulation Type" > "UFMC".
3. Select "General Settings" > "Allocation Settings".

The main part of the "Allocation Settings" dialog is the allocation table where the individual allocations can be defined. Each allocation can use different constellation/modulation and data source.

The allocations can differ in the used number of symbols, the occupied number of subcarriers, and the individual position within the time-frequency grid. Different users can be assigned to the allocations, where each user uses individual data source and multiple access schemes.

The "Time Plan" shows individual allocations on the time-frequency grid, see Chapter 3.3.7, "Time plan", on page 54.

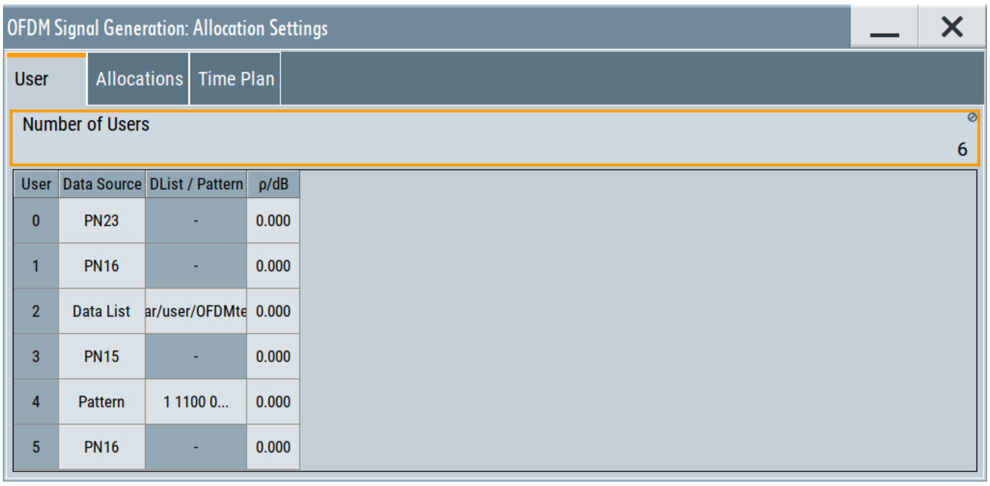
Settings:

- User settings....................42
- Allocations settings....................43
- Split pattern settings....................48
- SCMA settings....................49
- Zadoff-Chu settings....................52
- Constellation points settings....................53
- Time plan....................54

3.3.1 User settings

Access:

► Select "User".



Settings:

Number of Users..42
User...42
Data Source...42
ρ(dB)..43

Number of Users
Indicates the maximum number of users that can be configured.

Any configured user can be deactivated.

Remote command:
n.a.

User
Displays the consecutive number of the user.

Remote command:
Via suffix USER<ch0>

Data Source
The following standard data sources are available:
- "All 0, All 1"
  An internally generated sequence containing 0 data or 1 data.
- "PNxx"
  An internally generated pseudo-random noise sequence.
- "Pattern"
  An internally generated sequence according to a bit pattern.
  Use the "Pattern" box to define the bit pattern.
- "Data List/Select DList"

A binary data from a data list, internally or externally generated.
Select "Select DList" to access the standard "Select List" dialog.

- Select the "Select Data List > navigate to the list file *.dm_iqd > Select" to select an existing data list.
- Use the "New" and "Edit" functions to create internally new data list or to edit an existing one.
- Use the standard "File Manager" function to transfer external data lists to the instrument.

See also:

- Section "Modulation Data" in the R&S SMM100A user manual.
- Section "File and Data Management" in the R&S SMM100A user manual.
- Section "Data List Editor" in the R&S SMM100A user manual

Remote command:
[:SOURce<hw>]:BB:OFDM:USER<ch0>:DATA on page 77
[:SOURce<hw>]:BB:OFDM:USER<ch0>:LIST on page 77
[:SOURce<hw>]:BB:OFDM:USER<ch0>:PATTern on page 78

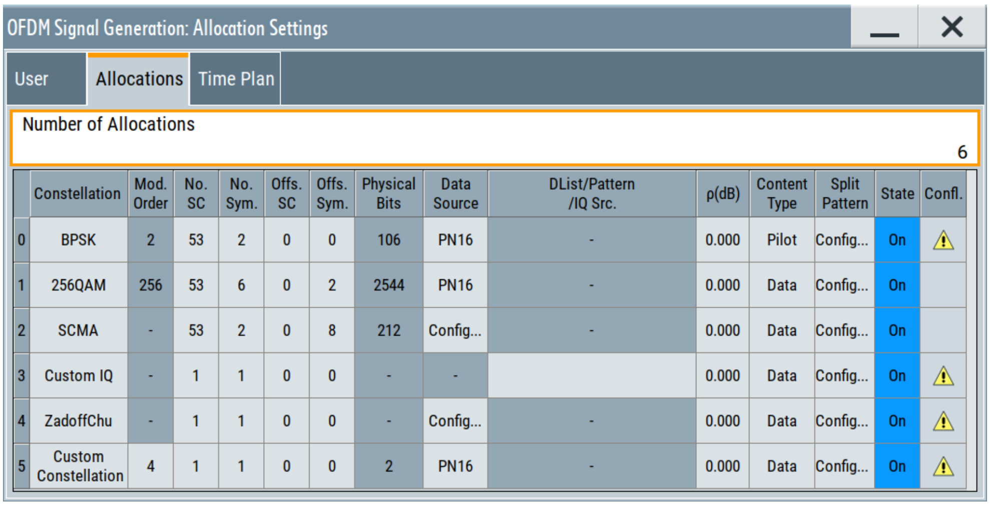
ρ(dB)
Boosts the user with the selected power offset relative to the other users.

Remote command:
[:SOURce<hw>]:BB:OFDM:USER<ch0>:PWR on page 78

3.3.2 Allocations settings

Access:

► Select "Allocations".



This tab provides settings to configure the number of allocations and individual allocation settings in a table.

Each row represents a configuration of an individual allocation. For each allocation, configure base modulation type, subcarriers and symbols, data source, power offset and time-frequency resources.
Use the Time plan to visualize the resulting resource grid assignments.

Settings:

Number of Allocations....44
Allocation number AL#....44
Constellation....44
Modulation Order....45
No. SC....45
No. Sym....45
Offs. SC....45
Offs. Sym....45
Physical Bits....45
Data Source....46
ρ(dB)....46
Content Type....47
Split Pattern....48
State....48
Conflict....48

Number of Allocations

Sets the number of scheduled allocations.

Remote command:
`[:SOURce<hw>]:BB:OFDM:NALLoc` on page 82

Allocation number AL#

Displays the consecutive number of the allocation.

Remote command:
n.a.

Constellation

Sets the constellation that is the base modulation type of the selected allocation.

"BPSK/QPSK" Binary/quarternary phase-shift keying

"16/64/256QAM"
16/64/256 quadrature amplitude modulation

"SCMA" Sparse code multiple access

"Custom IQ" Custom modulation of I/Q data from files
You can load files with predefined file syntax and file extension, see "Custom I/Q file format (*.iqw or *.dat files)" on page 24.

"ZadoffChu" Zadoff-Chu sequence
Also configure sequence settings such as the sequence length, the sequence number and the cyclic shifts, see Chapter 3.3.5, "Zadoff-Chu settings", on page 52.

"Custom Constellation"
Custom constellation with user-defined constellation points
Also configure modulation order and coordinates of individual constellation points, see Chapter 3.3.6, "Constellation points settings", on page 53.

Remote command:
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:MODulation on page 82

Modulation Order
Sets/displays the modulation order of the allocation.

Setting the modulation order requires "Constellation" > "Custom Constellation", see "Constellation" on page 44.

In the allocation table, this parameter accesses constellation points settings of the selected allocation, see Chapter 3.3.6, "Constellation points settings", on page 53.

Remote command:
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:MOOR on page 83

No. SC
Sets the number of allocated subcarriers that is the allocated bandwidth.

If SCMA is used, the number of allocated subcarries must be a multiple of the spreading factor K (see Spreading Factor K).

Remote command:
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCNO on page 83

No. Sym.
Sets the allocation size in the time domain as number of symbols.

Remote command:
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SYNO on page 83

Offs. SC
Sets the start subcarrier of the selected allocation. It shifts the allocated bandwidth in the frequency domain.

Remote command:
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCOFfset on page 84

Offs. Sym.
Sets the start symbol of the selected allocation. It shifts the allocation in the time domain.

Remote command:
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SYOFfset on page 84

Physical Bits
Displays the allocation size in bits.

The value depends on the allocation size and the used modulation.

Remote command:
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:PHYSbits? on page 84

Data Source
Selects the data source for the allocation.

"User x" Use the User settings dialog to configure the data sources for the "User 1 to 6".

"Config" If "Modulation" > "SCMA", opens a dialog with further settings, see Chapter 3.3.4, "SCMA settings", on page 49.

"I/Q Source" For "Modulation" > "Custom I/Q", select "Select IQ Source" to access the standard "Select List" dialog.
Select a suitable file with file extension the `*.dat` or `*.iqw`.
Use the standard "File Manager" function to transfer external data lists to the instrument. For information on the file format, see "Custom I/Q file format (*.iqw or *.dat files)" on page 24.

"All 0"/"All 1"/"PNxx"/"Pattern/"/"Data List"/"Select DList"
The following standard data sources are available:

- "All 0, All 1"
  An internally generated sequence containing 0 data or 1 data.
- "PNxx"
  An internally generated pseudo-random noise sequence.
- "Pattern"
  An internally generated sequence according to a bit pattern.
  Use the "Pattern" box to define the bit pattern.
- "Data List/Select DList"
  A binary data from a data list, internally or externally generated.
  Select "Select DList" to access the standard "Select List" dialog.
  – Select the "Select Data List > navigate to the list file *.dm_iqd > Select" to select an existing data list.
  – Use the "New" and "Edit" functions to create internally new data list or to edit an existing one.
  – Use the standard "File Manager" function to transfer external data lists to the instrument.

See also:

- Section "Modulation Data" in the R&S SMM100A user manual.
- Section "File and Data Management" in the R&S SMM100A user manual.
- Section "Data List Editor" in the R&S SMM100A user manual

Remote command:
`[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:DATA` on page 84
`[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:LIST` on page 85
`[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:PATTern` on page 85
`[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CIQFile` on page 85

ρ(dB)
Boosts the allocation with the selected power offset relative to the others.

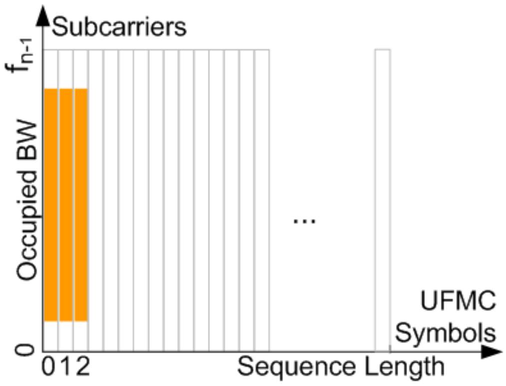
Remote command:
`[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:PWR` on page 85

Content Type

Sets the content type.

"Data" The allocation contains the data, selected with the parameter Data Source.

"Preamble" If UFMC modulation is used, the first allocation is always a preamble. Preambles are required to synchronize the R&S SMM100A and Rohde & Schwarz signal analyzer.
The preamble spans the entire occupied bandwidth and is located on the first up to 3 symbols, as set with the parameter No. Sym.. The preamble symbols are filled with a pseudo-random sequence (PN9) and are BPSK modulated. The pseudo-random generation restarts at the beginning of each symbol, so that the preamble symbols are identical.



The remaining symbols are filled with the data source and modulated as selected with the parameters Data Source and Constellation.
To set the preamble length, use the parameter No. Sym..

Note: Do not mistake the preamble with the cyclic prefix, see "Cyclic Prefix Length" on page 32.

"Pilot" If OFDM modulation is used, enables generation of pilot signals. Pilots are used by measurements with the Rohde & Schwarz signal analyzer, for example R&S®VSE-K96.

See also:

- Modulation Type > "f-OFDM".
- Chapter 2.5, "Generating configuration files for R&S®VSE-K96", on page 25

"Reserved" If OFDM modulation is used, you can mark allocations as reserved, so that they are perceived as general OFDM modulated signals by the analyzer.
The allocation configuration and content is user-defined. The signal generation is as for any other allocation content. This setting affects the content of the automatically created `*.xml` settings file and hence the way that the signal analyzer processes the generated signal.
See also Chapter 2.5, "Generating configuration files for R&S®VSE-K96", on page 25.

Remote command:
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CONTent on page 86

Split Pattern
Accesses split pattern settings for the selected allocation, see Chapter 3.3.3, "Split pattern settings", on page 48.

Remote command:
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:PATTern on page 85

State
Enables the allocation.

Remote command:
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:STATe on page 86

Conflict
Indicates a conflict, if allocations overlap.

To visualize the allocations, use the Time plan.

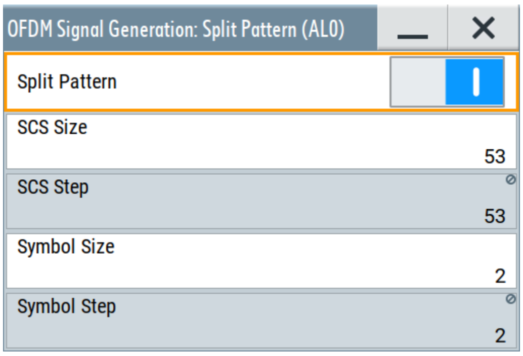
Remote command:
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CONFlict? on page 86

3.3.3 Split pattern settings

Access:

1. Select "Allocations".
2. Select "AL#" > "Split Pattern" > "Config".

   The "Split Pattern" dialog of the selected allocation "(AL#)" opens. It allows you to configure subcarrier spacing (SCS) size and SCS step and symbol size and symbol step.



Settings:

Split Pattern....................49
SCS Size....................49
SCS Step....................49
Symbol Size....................49
Symbol Step....................49

Split Pattern
Activates split pattern settings for the selected allocation.

Remote command:
`[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SPLT:STATe` on page 89

SCS Size
Sets the subcarrier spacing (SCS) size.

The maximum SCS size equals the number of subcarriers of the selected allocation, see "No. SC" on page 45.

Remote command:
`[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SPLT:SCS:SIZE` on page 89

SCS Step
Sets/displays the subcarrier spacing (SCS) step.

Setting requires SCS sizes smaller than the set number of subcarriers of the selected allocation, see "SCS Size" on page 49.

Remote command:
`[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SPLT:SCS:STEP` on page 90

Symbol Size
Sets the symbol size.

The maximum symbol size equals the number of symbols of the selected allocation, see "No. Sym." on page 45.

Remote command:
`[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SPLT:SYM:SIZE` on page 90

Symbol Step
Sets/displays the symbol step.

Setting requires symbol sizes smaller than the number of symbols of the selected allocation.

Remote command:
`[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SPLT:SYM:STEP` on page 90

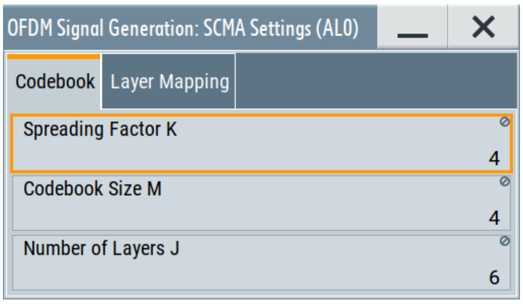
3.3.4 SCMA settings

Access:

1. Select "Allocations".

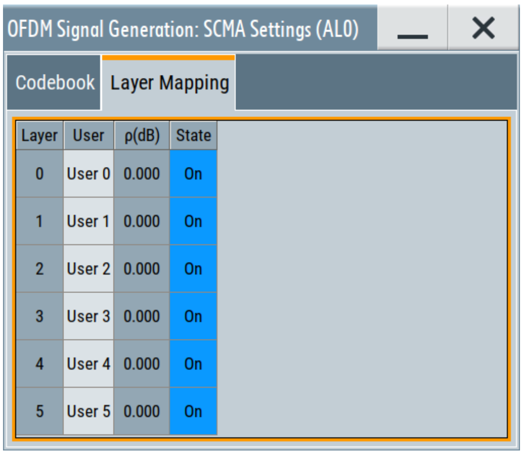
2. Select "AL#" > "Constellation" > "SCMA".
3. Select "Data Source" > "Config".

   The "SCMA Settings" dialog of the selected allocation "(AL#)" opens. In the "Codebook" tab, configure spreading factor, codebook size and number of layers.



4. Select "Layer Mapping".

   In the "Layer Mapping" tab, assign users to individual layers and configure the state of these layers.



Settings:

Codebook....................50
└ Spreading Factor K....................51
└ Codebook Size M....................51
└ Number of Layers J....................51
Layer Mapping....................51
└ Layer....................51
└ User....................51
└ ρ(dB)....................51
└ State....................51

Codebook

Displays the codebook parameters.

See Figure 2-8.

Spreading Factor K ← Codebook
Displays the used spreading factor K.

Remote command:
`[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCMA:SPRead?` on page 87

Codebook Size M ← Codebook
Displays the codebook size M.

Remote command:
`[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCMA:CODebook?` on page 87

Number of Layers J ← Codebook
Displays the resulting number of layers J.

The number of layers (that is also the number of codebooks) is calculated as follows:

$$J = \binom{K}{N}$$

Where:
- K is the spreading factor
- N is the number of non-zero elements, see Figure 2-8.

With the predefined settings, the number of layers is J = 6.

Remote command:
`[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCMA:NLAYers?` on page 87

Layer Mapping
Comprises the user to layer-mapping settings:

Layer ← Layer Mapping
Indicates the layer number.

With the predefined settings, the number of layers is J = 6, see Number of Layers J.

User ← Layer Mapping
Maps the users to the layers and sets the codebook per user, see for example Figure 2-9.

One user can be assigned to several layers, whereas each layer can be assigned to exact one user.

Remote command:
`[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCMA:LAYer<st0>:USER` on page 88

ρ(dB) ← Layer Mapping
Provided for future use.

Remote command:
`[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCMA:LAYer<st0>:PWR?` on page 87

State ← Layer Mapping
Enables the individual layers (codebooks).

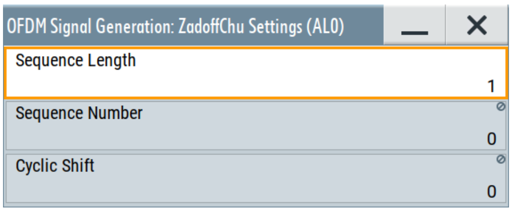
Remote command:
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCMA:LAYer<st0>:STATe on page 88

3.3.5 Zadoff-Chu settings

Access:

1. Select "Allocations".
2. Select "AL#" > "Constellation" > "ZadoffChu".
3. Select "Data Source" > "Config".

   The "ZadoffChu Settings" dialog of the selected allocation "(AL#)" opens. It provides settings to configure sequence length, number of sequences and cyclic shifts of the Zadoff-Chu sequence.



Settings:

Sequence Length....52
Sequence Number....52
Cyclic Shift....52

Sequence Length
Sets the length of the Zadoff-Chu sequence.

The maximum sequence length equals the number of subcarriers of the allocation, see "No. SC" on page 45.

Remote command:
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:ZAD:SLEN on page 91

Sequence Number
Sets the sequence number within the Zadoff-Chu sequence.

Remote command:
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:ZAD:SNUMber on page 91

Cyclic Shift
Sets the cyclic shift of the Zadoff-Chu sequence.

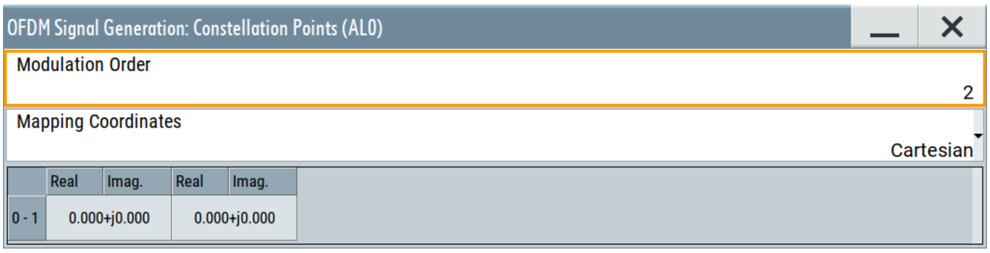
Remote command:
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:ZAD:CYCShift on page 91

3.3.6 Constellation points settings

Access:

1. Select "Allocations".
2. Select "AL#" > "Constellation" > "Custom Constellation".
3. Select "Mod. Order".

   The "Constellation Points" dialog of the selected allocation "(AL#)" opens. It provides settings to configure the modulation order, the reference coordinate system and constellation point coordinates of an individual allocation.



Settings:

Modulation Order 53
Mapping Coordinates 53
Constellation coordinates table 53

Modulation Order

Sets/displays the modulation order of the allocation.

Setting the modulation order requires "Constellation" > "Custom Constellation", see "Constellation" on page 44.

In the allocation table, this parameter accesses constellation points settings of the selected allocation, see Chapter 3.3.6, "Constellation points settings", on page 53.

Remote command:
`[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:MOOR` on page 83

Mapping Coordinates

Sets the reference coordinate system of the constellation points.

"Cartesian"	Cartesian coordinate system with real part and imaginary part coordinates.
"Cylindrical"	Cylindrical coordinate system with magnitude and phase coordinates.

Remote command:
n.a.

Constellation coordinates table

Sets coordinates for individual constellation points.

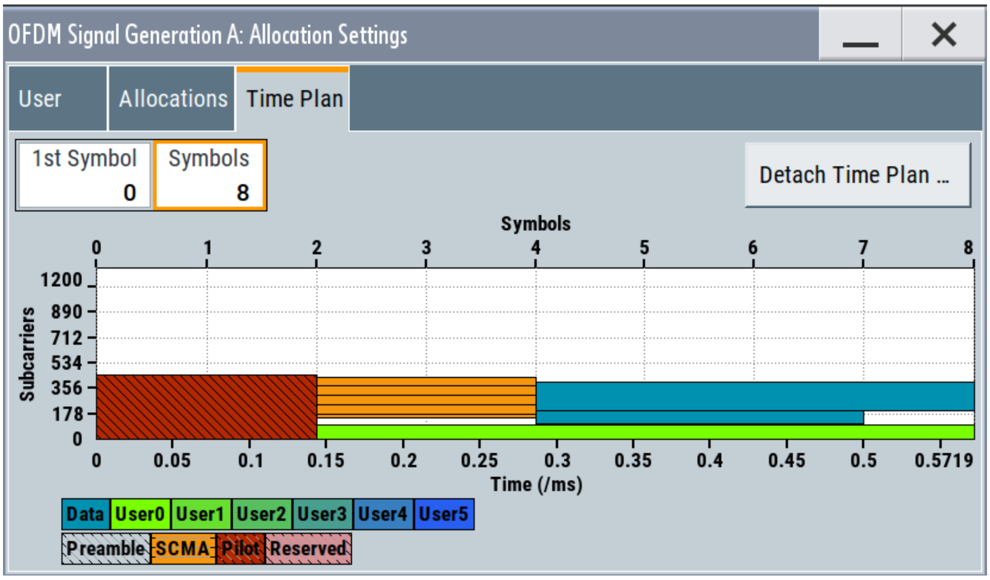
You can set real part (x-axis) and imaginary part (y-axis) coordinates for a cartesian coordinate system. Or you can set phase and magnitude coordinates for a cylindrical coordinate system. See "Mapping Coordinates" on page 53.

Remote command:
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CONPoint<st0>:REAL on page 93
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CONPoint<st0>:IMAG on page 92
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CONPoint<st0>:MAGN on page 93
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CONPoint<st0>:PHASe on page 93

3.3.7 Time plan

Access:

1. Select "Allocation Settings".
2. Select "Time Plan".



The x-axis shows allocation in the time domain, expressed in both time and number of symbols. The y-axis shows the occupied subcarriers as smallest allocation granularity in the frequency domain.

Settings:

1st Symbol... 54
Symbols.. 55
Detach Time Plan...55

1st Symbol

Selects the number of the first displayed symbol.

Remote command:
n.a.

Symbols
Sets the number of displayed symbols.

The maximum number of symbols is set with the parameter Sequence Length.

Remote command:
n.a.

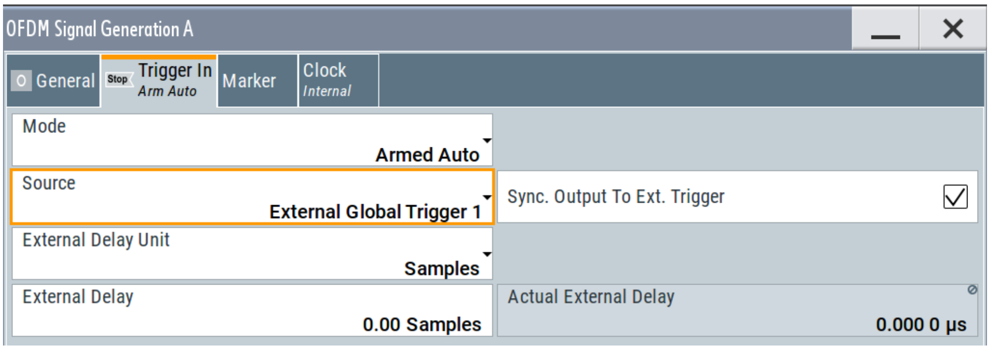
Detach Time Plan
Opens the time plan in a separate window.

Remote command:
n.a.

3.4 Trigger settings

Access:

► Select "OFDM Signal Generation" > "Trigger In".



This tab provides settings to select and configure the trigger, like trigger source, trigger mode and trigger delays, and to arm or trigger an internal trigger manually. The header of the tab displays the status of the trigger signal and trigger mode. As in the tabs "Marker" and "Clock", this tab provides also access to the settings of the related connectors.

Routing and activating a trigger signal

1. Define the effect of a trigger event and the trigger signal source.
   a) Select "Trigger In" > "Mode".
   b) Select "Trigger In" > "Source".
2. For external trigger signals, define the connector for signal input. See Chapter 3.7, "Local and global connectors settings", on page 63.
   You can map trigger signals to one or more User x or T/M connectors.

   Local and global connectors settings allow you to configure the signal mapping, the polarity, the trigger threshold and the input impedance of the input connectors.
3. Activate baseband signal generation. In the block diagram, set "Baseband" > "On".

The R&S SMM100A starts baseband signal generation after the configured trigger event.

About baseband trigger signals

This section focuses on the available settings.

For information on how these settings affect the signal, refer to section "Basics on ..." in the R&S SMM100A user manual.

Settings:

Mode....56
Signal Duration Unit....57
Signal Duration....57
Running/Stopped....57
Time Based Trigger....57
Trigger Time....57
Arm....58
Execute Trigger....58
Source....58
Sync. Output to External Trigger/Sync. Output to Trigger....58
External Inhibit/Trigger Inhibit....59
(External) Delay Unit....59
(Specified) External Delay/(Specified) Trigger Delay....60
Actual Trigger Delay/Actual External Delay....60

Mode

Selects trigger mode, i.e. determines the effect of a trigger event on the signal generation.

- "Auto"
  The signal is generated continuously.
- "Retrigger"
  The signal is generated continuously. A trigger event (internal or external) causes a restart.
- "Armed Auto"
  The signal is generated only when a trigger event occurs. Then the signal is generated continuously.
  An "Arm" stops the signal generation. A subsequent trigger event (internal or external) causes a restart.
- "Armed Retrigger"
  The signal is generated only when a trigger event occurs. Then the signal is generated continuously. Every subsequent trigger event causes a restart.
  An "Arm" stops signal generation. A subsequent trigger event (internal or external) causes a restart.
- "Single"
  The signal is generated only when a trigger event occurs. Then the signal is generated once to the length specified at "Signal Duration".
  Every subsequent trigger event (internal or external) causes a restart.

Remote command:
[:SOURce<hw>]:BB:OFDM[:TRIGger]:SEQuence on page 95

Signal Duration Unit
Defines the unit for describing the length of the signal sequence to be output in the "Single" trigger mode.

Remote command:
[:SOURce<hw>]:BB:OFDM:TRIGger:SLUNit on page 97

Signal Duration
Requires trigger "Mode" > "Single".

Enters the length of the trigger signal sequence.

Use this parameter, for example, for the following applications:
- To output the trigger signal partly.
- To output a predefined sequence of the trigger signal.

Remote command:
[:SOURce<hw>]:BB:OFDM:TRIGger:SLENgth on page 97

Running/Stopped
With enabled modulation, displays the status of signal generation for all trigger modes.

- "Running"
  The signal is generated; a trigger was (internally or externally) initiated in triggered mode.
- "Stopped"
  The signal is not generated and the instrument waits for a trigger event.

Remote command:
[:SOURce<hw>]:BB:OFDM:TRIGger:RMODe? on page 95

Time Based Trigger
Requires trigger "Mode" > "Armed Auto"/"Single".

Activates time-based triggering with a fixed time reference.

The R&S SMM100A triggers signal generation when its operating system time ("Current Time") matches a specified time trigger ("Trigger Time"). As trigger source, you can use an internal trigger or an external global trigger.

How to: Chapter "Time-based triggering" in the R&S SMM100A user manual.

Remote command:
[:SOURce<hw>]:BB:OFDM:TRIGger:TIME[:STATe] on page 97

Trigger Time
Requires trigger "Mode" > "Armed Auto"/"Single".

Sets date and time for a time-based trigger signal.

Set a trigger time that is later than the "Current Time". The current time is the operating system time of the R&S SMM100A. If you set an earlier trigger time than the current time, time-based triggering is not possible.

How to: Chapter "Time-based triggering" in the R&S SMM100A user manual.

"Date" Sets the date of the time-based trigger in format YYYY-MM-DD.

Remote command:
[:SOURce<hw>]:BB:OFDM:TRIGger:TIME:DATE on page 96

"Time" Sets the time of the time-based trigger in format hh:mm:ss.

Remote command:
[:SOURce<hw>]:BB:OFDM:TRIGger:TIME:TIME on page 96

Arm
Stops the signal generation until subsequent trigger event occurs.

Remote command:
[:SOURce<hw>]:BB:OFDM:TRIGger:ARM:EXECute on page 98

Execute Trigger
For internal trigger source, executes trigger manually.

Remote command:
[:SOURce<hw>]:BB:OFDM:TRIGger:EXECute on page 97

Source
The following sources of the trigger signal are available:

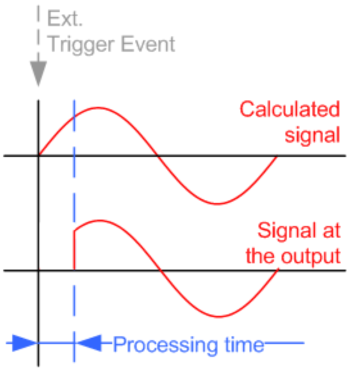
- "Internal"
  The trigger event is executed manually by the "Execute Trigger".
- "External Global Trigger"
  The trigger event is the active edge of an external trigger signal provided and configured at the User x connectors.
- "Baseband Sync In"
  In primary-secondary instrument mode, secondary instruments are triggered by the active edge of the synchronization signal.

How to: "Routing and activating a trigger signal" on page 55

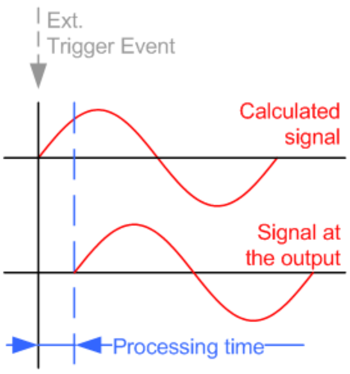
Remote command:
[:SOURce<hw>]:BB:OFDM:TRIGger:SOURce on page 95

Sync. Output to External Trigger/Sync. Output to Trigger
Enables signal output synchronous to the trigger event.

- "On"
  Corresponds to the default state of this parameter.
  The signal calculation starts simultaneously with the trigger event. Because of the processing time of the instrument, the first samples are cut off and no signal is output. After elapsing of the internal processing time, the output signal is synchronous to the trigger event.



- "Off"
  The signal output begins after elapsing of the processing time. Signal output starts with sample 0. The complete signal is output.
  This mode is recommended for triggering of short signal sequences. Short sequences are sequences with signal duration comparable with the processing time of the instrument.



Remote command:
`[:SOURce<hw>]:BB:OFDM:TRIGger:EXTernal:SYNChronize:OUTPut`
on page 98

External Inhibit/Trigger Inhibit
Applies for external trigger signal.

Sets the duration with that any following trigger event is suppressed. In "Retrigger" mode, for example, a new trigger event does not cause a restart of the signal generation until the specified inhibit duration does not expire.

For more information, see chapter "Basics" in the R&S SMM100A user manual.

Remote command:
`[:SOURce<hw>]:BB:OFDM:TRIGger[:EXTernal]:INHibit` on page 99

(External) Delay Unit
Determine whatever the trigger delay is expressed in samples or directly defined as a time period (seconds).

To specify the delay, use the parameter (Specified) External Delay/(Specified) Trigger Delay.

The parameter Actual Trigger Delay/Actual External Delay displays the delay converted in time.

Remote command:
`[:SOURce<hw>]:BB:OFDM:TRIGger:DELay:UNIT` on page 98

(Specified) External Delay/(Specified) Trigger Delay
The name of the parameter and the units the delay is expressed in, changes depending on the parameter (External) Delay Unit.

Delays the trigger event of the signal from:
- The external trigger source

Use this setting to:
- Synchronize the instrument with the device under test (DUT) or other external devices

For more information, see chapter "Basics on ..." in the R&S SMM100A user manual.

The parameter displays the delay converted in time.

Remote command:
`[:SOURce<hw>]:BB:OFDM:TRIGger[:EXTernal]:DELay` on page 98
`[:SOURce<hw>]:BB:OFDM:TRIGger:EXTernal:TDELay` on page 99

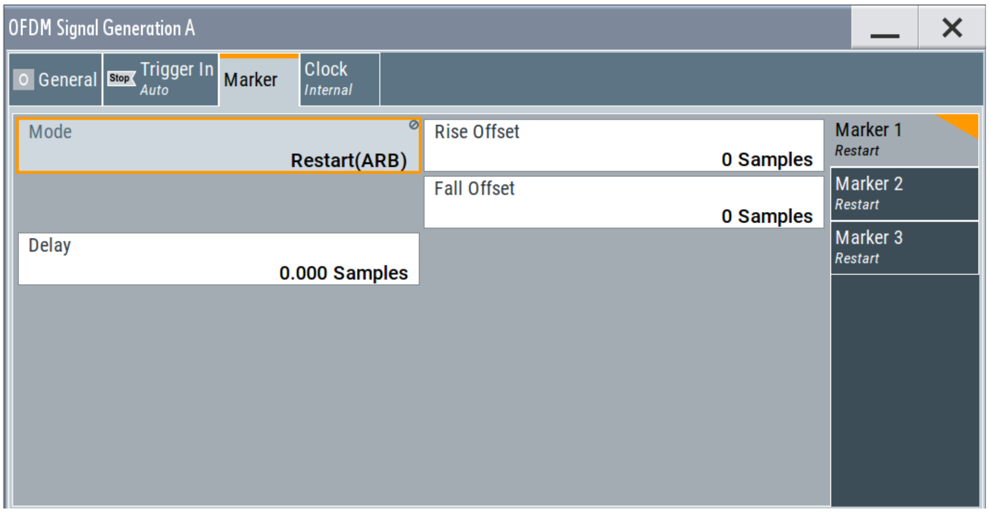
Actual Trigger Delay/Actual External Delay
Indicates the resulting trigger delay in "Time" unit.

Remote command:
`[:SOURce<hw>]:BB:OFDM:TRIGger:EXTernal:RDELay?` on page 99

3.5 Marker settings

Access:

► Select "OFDM Signal Generation" > "Marker".



This tab provides settings to select and configure the marker output signal including marker mode and marker delay.

Routing and activating a marker signal

1. To define the signal shape of an individual marker signal "x", select "Marker" > "Marker x" > "Mode".
2. Optionally, define the connector for signal output. See Chapter 3.7, "Local and global connectors settings", on page 63.
   You can map marker signals to one or more User x or T/M connectors.
3. Activate baseband signal generation. In the block diagram, set "Baseband" > "On".
   The R&S SMM100A adds the marker signal to the baseband signal. Also, R&S SMM100A outputs this signal at the configured User x connector.

About marker output signals

This section focuses on the available settings.

For information on how these settings affect the signal, refer to section "Basics on ..." in the R&S SMM100A user manual.

Settings:

Mode....61
Rise Offset/Fall Offset....61
Delay....61

Mode

Marker configuration for up to 3 markers. The settings are used to select the marker mode defining the shape and periodicity of the markers. The contents of the dialog change with the selected marker mode.

How to: "Routing and activating a marker signal" on page 61

"Restart (ARB)"
A marker signal is generated at the start of each ARB sequence.

Remote command:
`[:SOURce<hw>]:BB:OFDM:TRIGger:OUTPut<ch>:MODE` on page 100

Rise Offset/Fall Offset

Shifts the rising or falling ramp of the marker by the selected number of samples. Positive values shift the rising ramp to later positions; negative values shift it to earlier positions.

Remote command:
`[:SOURce<hw>]:BB:OFDM:TRIGger:OUTPut<ch>:FOFFset` on page 100
`[:SOURce<hw>]:BB:OFDM:TRIGger:OUTPut<ch>:ROFFset` on page 100

Delay

Delays the marker signal at the marker output relative to the signal generation start.

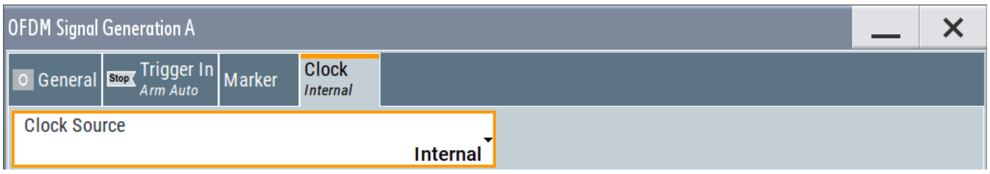
Variation of the parameter "Marker x" > "Delay" causes signal recalculation.

Remote command:
[:SOURce<hw>]:BB:OFDM:TRIGger:OUTPut<ch>:DELay on page 100

3.6 Clock settings

Access:

► Select "OFDM Signal Generation" > "Clock".



This tab provides settings to select and configure the clock signal, like the clock source and clock mode.

Defining the clock

1. Select "Clock" > "Source" to define the source of clock signal.
2. For external clock signals, define the connector for signal input. See Chapter 3.7, "Local and global connectors settings", on page 63.
   You can map clock signals to one or more User x or T/M connectors.

   Local and global connectors settings allow you to configure the signal mapping, the polarity, the trigger threshold and the input impedance of the input connectors.
3. Activate baseband signal generation. In the block diagram, set "Baseband" > "On".

   The R&S SMM100A starts baseband signal generation with a symbol rate that equals the clock rate.

About clock signals

This section focuses on the available settings.

For information on how these settings affect the signal, refer to section "Basics on ..." in the R&S SMM100A user manual.

Settings:

Clock Source..62

Clock Source
Selects the clock source.

- "Internal"
  The instrument uses its internal clock reference.

Remote command:
[:SOURce<hw>]:BB:OFDM:CLOCk:SOURce on page 101

3.7 Local and global connectors settings

Accesses a dialog to configure local connectors or global connectors.

The button is available in the following dialogs or tabs:

- "Trigger / Marker / Clock" dialog that is accessible via the "TMC" block in the block diagram.
- "Trigger In", "Marker" and "Clock" tabs that are accessible via the "Baseband" block in the block diagram.

See also chapter "Local and global connectors settings" in the user manual.

4 Remote-control commands

The following commands are required to perform signal generation with the option R&S SMM100A-K114 in a remote environment. We assume that the R&S SMM100A has already been set up for remote operation in a network as described in the R&S SMM100A documentation. A knowledge about the remote control operation and the SCPI command syntax are assumed.

Conventions used in SCPI command descriptions

For a description of the conventions used in the remote command descriptions, see section "Remote Control Commands" in the R&S SMM100A user manual.

Common Suffixes

The following common suffixes are used in the remote commands:

Suffix	Value range	Description
`ENTity<ch>`	1	Optional keyword, provided for compatibility with R&S®SMW200A `ENTity1:SOURce1` = `SOURce1`
`SOURce<hw>`	1	Available baseband signals
`OUTPut<ch>`	1 to 3	Available markers
`USER<ch>`	0 to 5	Available users
`ALLoc<ch0>`	0 to 499	Available allocations
`CONPoint<st0>`	0 to 4095	Available constellation points for custom constellation

Programming examples

This description provides simple programming examples. The purpose of the examples is to present **all** commands for a given task. In real applications, one would rather reduce the examples to an appropriate subset of commands.

The programming examples have been tested with a software tool which provides an environment for the development and execution of remote tests. To keep the example as simple as possible, only the "clean" SCPI syntax elements are reported. Non-executable command lines (e.g. comments) start with two // characters.

At the beginning of the most remote control program, an instrument preset or reset is recommended to set the instrument to a definite state. The commands `*RST` and `SYSTem:PRESet` are equivalent for this purpose. `*CLS` also resets the status registers and clears the output buffer.

The following commands specific to the R&S SMM100A-K114 option are described here:

- General commands......65
- Physical commands......68
- Filter commands......73

- Modulation commands.....76
- User commands.....77
- Allocation commands.....79
- Trigger commands.....94
- Marker commands.....100
- Clock commands.....101

4.1 General commands

Example: Saving current configuration

```
SOURce1:BB:OFDM:SETTing:STORe "/var/user/5g_ufmc_scma"
*RST
SOURce1:BB:OFDM:SETTing:CATalog?
// Response: "5g_ufmc_scma", "5g"
SOURce1:BB:OFDM:SETTing:LOAD "/var/user/5g_ufmc_scma"
SOURce1:BB:OFDM:NALLoc?
// 6
SOURce1:BB:OFDM:SETTing:DEL "5g"
```

Example: Saving a configuration to an XML file

```
SOURce1:BB:OFDM:MODulation OFDM
SOURce1:BB:OFDM:OUTPath "/var/user/K114-Export/"
SOURce1:BB:OFDM:STATe 1
// Query the created *.xml file.
SOURce1:BB:OFDM:OUTPath? "/var/user/K114-Export/Exported_K114_settings_K96"
```

[:SOURce<hw>]:BB:OFDM:STATe.....65
[:SOURce<hw>]:BB:OFDM:PRESet.....66
[:SOURce<hw>]:BB:OFDM:SETTing:CATalog.....66
[:SOURce<hw>]:BB:OFDM:SETTing:LOAD.....66
[:SOURce<hw>]:BB:OFDM:SETTing:STORe.....66
[:SOURce<hw>]:BB:OFDM:SETTing:DEL.....67
[:SOURce<hw>]:BB:OFDM:WAVeform:CREate.....67
[:SOURce<hw>]:BB:OFDM:MODulation.....67
[:SOURce<hw>]:BB:OFDM:MODPreset.....67
[:SOURce<hw>]:BB:OFDM:OUTPath.....67
[:SOURce<hw>]:BB:OFDM:SRATe:VARiation.....68

[:SOURce<hw>]:BB:OFDM:STATe <State>

Activates the standard.

Parameters:

<State> 1 | ON | 0 | OFF

*RST: 0

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "State" on page 28

[:SOURce<hw>]:BB:OFDM:PRESet

Sets the parameters of the digital standard to their default values (*RST values specified for the commands).

Not affected is the state set with the command SOURce<hw>:BB:OFDM:STATe.

Example: See Example"Generating a UFMC waveform" on page 79.

Usage: Event

Manual operation: See "Set to Default" on page 28

[:SOURce<hw>]:BB:OFDM:SETTing:CATalog

Queries the files with settings in the default directory. Listed are files with the file extension *.c5g.

Example: See Example"Saving current configuration" on page 65.

Manual operation: See "Save/Recall" on page 28

[:SOURce<hw>]:BB:OFDM:SETTing:LOAD <Filename>

Loads the selected file from the default or the specified directory. Loaded are files with extension *.c5g.

Parameters:

<Filename> string

file name or complete file path; file extension can be omitted

Example: See Example"Saving current configuration" on page 65.

Manual operation: See "Save/Recall" on page 28

[:SOURce<hw>]:BB:OFDM:SETTing:STORe <Filename>

Stores the current settings into the selected file; the file extension (*.c5g) is assigned automatically.

Parameters:

<Filename> string

file name or complete file path

Example: See Example"Saving current configuration" on page 65.

Manual operation: See "Save/Recall" on page 28

[:SOURce<hw>]:BB:OFDM:SETTing:DEL <Filename>

Deletes the selected file from the default or specified directory. Deleted are files with the file extension `*.c5g`.

Parameters:

<Filename> string

file name or complete file path; file extension can be omitted

Example: See Example"Saving current configuration" on page 65.

Manual operation: See "Save/Recall" on page 28

[:SOURce<hw>]:BB:OFDM:WAVeform:CREate <Filename>

Stores the current settings as an ARB signal in a waveform file (`*.wv`).

Parameters:

<Filename> string

file name or complete file path; file extension is assigned automatically

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Generate Waveform File" on page 28

[:SOURce<hw>]:BB:OFDM:MODulation <ModType>

Selects the modulation type.

Parameters:

<ModType> UFMC | FBMC | GFDM | FOFDm | OFDM

*RST: OFDM

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Modulation Type" on page 29

[:SOURce<hw>]:BB:OFDM:MODPreset

Calls the default settings for the selected modulation type, see `[:SOURce<hw>]:BB:OFDM:MODulation` on page 67.

Example: See Example"Generating a UFMC waveform" on page 79.

Usage: Event

Manual operation: See "Set to Modulation Default" on page 30

[:SOURce<hw>]:BB:OFDM:OUTPath <K114OutputPath>

Specifies the output path and output file of the exported OFDM signal generation settings.

By default, the output path is `/var/user/K114-Export` and the output file is `Exported_K114_settings_K96.xml`.

See also Example"Default "Exported_K114_settings_K96.xml" file" on page 102.

Parameters:

<K114OutputPath> string

Example: See Example"Saving a configuration to an XML file" on page 65.

Manual operation: See "Export path for XML settings ..." on page 29

[:SOURce<hw>]:BB:OFDM:SRATe:VARiation <SymRateVar>

Sets the symbol rate variation of the signal.

Parameters:

<SymRateVar> float

Range: 400 to 4E7
Increment: 1E-3
*RST: 15.360000E6

Example: See Example"Generating a UFMC waveform" on page 79.

4.2 Physical commands

[:SOURce<hw>]:BB:OFDM:NSUBcarriers.......68
[:SOURce<hw>]:BB:OFDM:NOCCupied.......69
[:SOURce<hw>]:BB:OFDM:SCSPace.......69
[:SOURce<hw>]:BB:OFDM:SEQLength.......69
[:SOURce<hw>]:BB:OFDM:CPLength.......69
[:SOURce<hw>]:BB:OFDM:ACPLength.......70
[:SOURce<hw>]:BB:OFDM:ACPSymbols.......70
[:SOURce<hw>]:BB:OFDM:CPSYmbols.......70
[:SOURce<hw>]:BB:OFDM:CSLength.......71
[:SOURce<hw>]:BB:OFDM:DFTS:STATe.......71
[:SOURce<hw>]:BB:OFDM:DCMode.......71
[:SOURce<hw>]:BB:OFDM:SAMPling?.......71
[:SOURce<hw>]:BB:OFDM:BWOCcupied?.......72
[:SOURce<hw>]:BB:OFDM:LGUard?.......72
[:SOURce<hw>]:BB:OFDM:RGUard?.......72

[:SOURce<hw>]:BB:OFDM:NSUBcarriers <NoOfSubCarr>

Sets the number of available subcarriers.

Parameters:

<NoOfSubCarr> integer

Range: 64 to 16384
*RST: 64

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Total Number Of Subcarriers" on page 31

[:SOURce<hw>]:BB:OFDM:NOCCupied <NumOccSc>

Sets the number of occupied subcarriers.

Parameters:

<NumOccSc> integer

Range: 1 to 13107
*RST: 53

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Occupied Number of Subcarriers" on page 31

[:SOURce<hw>]:BB:OFDM:SCSPace <SubCarSp>

Sets the frequency distance between the carrier frequencies of the subcarriers.

Parameters:

<SubCarSp> float

Range: 0.001 to 2
Increment: 1E-6
*RST: 0.3125
Default unit: MHz

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Subcarrier Spacing" on page 32

[:SOURce<hw>]:BB:OFDM:SEQLength <SeqLen>

Sets the sequence length of the signal in number of symbols.

Parameters:

<SeqLen> integer

Range: 1 to 1000
*RST: 10

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Sequence Length" on page 32

[:SOURce<hw>]:BB:OFDM:CPLength <CpLength>

Sets the cyclic prefix length as number of samples. The maximum length equals the total number of sucarriers:

`[:SOURce<hw>]:BB:OFDM:NSUBcarriers` on page 68

Parameters:

<CpLength> integer

Range: 0 to depends on settings
*RST: 16

Example: See Example"Generating a UFMC waveform" on page 79.

Example: See also [:SOURce<hw>]:BB:OFDM:ACPLength on page 70.

Manual operation: See "Cyclic Prefix Length" on page 32

[:SOURce<hw>]:BB:OFDM:ACPLength <CpLength>

For f-OFDM/OFDM, enables additional alternative CP.

Parameters:

<CpLength> integer

Range: 0 to 8192
*RST: 0

Example:

```
SOURce1:BB:OFDM:MODulation FOFD
SOURce1:BB:OFDM:NSUBcarriers 512
SOURce1:BB:OFDM:NOCCupied 400
SOURce1:BB:OFDM:SCSPace 0.05
SOURce1:BB:OFDM:SEQLength 8

SOURce1:BB:OFDM:CPLength1 160
SOURce1:BB:OFDM:CPSYmbols1 1
SOURce1:BB:OFDM:CPLength2 144
SOURce1:BB:OFDM:CPSYmbols2 7
// the CP in the first symbol is 1600 samples long
// the other 7 symbols use a CP with 144 samples
```

Manual operation: See "Alt. Cyclic Prefix Length" on page 33

[:SOURce<hw>]:BB:OFDM:ACPSymbols <CPSymbols>
[:SOURce<hw>]:BB:OFDM:CPSYmbols <CPSymbols>

For f-OFDM/OFDM, defines number of symbols on that the cyclic prefix/the alternative cyclic prefix is applied.

Parameters:

<CPSymbols> integer

Range: 0 to 8192
*RST: 1

Example: See [:SOURce<hw>]:BB:OFDM:ACPLength on page 70.

Manual operation: See "CP No. Symbols/Alt. CP No. Symbols" on page 34

[:SOURce<hw>]:BB:OFDM:CSLength <CycSuffLen>

Sets the cyclic suffix length. The maximum length equals the total number of sucarriers:

[:SOURce<hw>]:BB:OFDM:NSUBcarriers on page 68

Parameters:

<CycSuffLen> integer

Range: 0 to depends on settings
*RST: 0

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Cyclic Suffix Length" on page 35

[:SOURce<hw>]:BB:OFDM:DFTS:STATe <DftsState>

Activates discrete Fourier transform spread OFDM (DFT-s-OFDM) uplink scheme.

Parameters:

<DftsState> 1 | ON | 0 | OFF

*RST: 0

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "DFT-S (skip non-data)" on page 35

[:SOURce<hw>]:BB:OFDM:DCMode <DCMode>

Sets the DC subcarrier mode.

Parameters:

<DCMode> UTIL | PUNC | SKIP

UTIL
Uses the DC subcarrier for all allocations.

PUNC
Replaces the DC subcarrier by zeroes for all allocations.

SKIP
Skips the DC subcarrier in the discrete Fourier transformation (DFT).

*RST: UTIL

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "DC Mode" on page 35

[:SOURce<hw>]:BB:OFDM:SAMPling?

Queries the sampling rate.

Return values:

<SampRate> float

Range: 0.001 to 1000
Increment: 1E-3
*RST: 25.6
Default unit: MHz

Example: See Example"Generating a UFMC waveform" on page 79.

Usage: Query only

Manual operation: See "Sampling Rate" on page 35

[:SOURce<hw>]:BB:OFDM:BWOCcupied?

Queries the occupied bandwidth.

Return values:

<OccBw> float

Range: 0.001 to 1000
Increment: 1E-3
*RST: 20.45
Default unit: MHz

Example: See Example"Generating a UFMC waveform" on page 79.

Usage: Query only

Manual operation: See "Occupied Bandwidth" on page 36

[:SOURce<hw>]:BB:OFDM:LGUard?

Queries the number of left guard subcarriers.

Return values:

<LeftGuardSC> integer

Range: 0 to 1000
*RST: 52

Example: See Example"Generating a UFMC waveform" on page 79.

Usage: Query only

Manual operation: See "Number Of Left/Right Guard Subcarriers" on page 36

[:SOURce<hw>]:BB:OFDM:RGUard?

Queries the number of right guard subcarriers.

Return values:

<RightGuardSC> integer

Range: 0 to 1000
*RST: 51

Example: See Example"Generating a UFMC waveform" on page 79.

Usage: Query only

Manual operation: See "Number Of Left/Right Guard Subcarriers" on page 36

4.3 Filter commands

Example: Configuring filter settings

```
SOURce1:BB:OFDM:MODulation FOFD
SOURce1:BB:OFDM:FILTer:LENGth 74
SOURce1:BB:OFDM:FILTer:WINDowing HANN
SOURce1:BB:OFDM:FILTer:CUTTrans 1

SOURce1:BB:OFDM:MODulation GFDM
SOURce1:BB:OFDM:FILTer:TYPE?
// DIR
SOURce1:BB:OFDM:FILTer:ROLLoff?
// 0.1
SOURce1:BB:OFDM:FILTer:TYPE USER
SOURce1:BB:OFDM:FILTer:UCATalog?
// my_filter
SOURce1:BB:OFDM:FILTer:USELection "/var/user/my_filter.dat"
```

[:SOURce<hw>]:BB:OFDM:FILTer:TYPE 73
[:SOURce<hw>]:BB:OFDM:FILTer:ROLLoff 74
[:SOURce<hw>]:BB:OFDM:FILTer:LENGth 74
[:SOURce<hw>]:BB:OFDM:FILTer:SBATtenuation 74
[:SOURce<hw>]:BB:OFDM:FILTer:CUTTrans 74
[:SOURce<hw>]:BB:OFDM:FILTer:WINDowing 75
[:SOURce<hw>]:BB:OFDM:FILTer:UCATalog? 75
[:SOURce<hw>]:BB:OFDM:FILTer:USELection 75
[:SOURce<hw>]:BB:OFDM:FILTer:ULENgth? 75

[:SOURce<hw>]:BB:OFDM:FILTer:TYPE <FilterType>

Sets the baseband filter type.

Parameters:

<FilterType> RC | RRC | DIRichlet | RECT | DCH | STRunc | USER | PHYDyas | NONE

*RST: DCH

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Filter Type" on page 37

[:SOURce<hw>]:BB:OFDM:FILTer:ROLLoff <RollOff>

Sets the filter parameter.

Parameters:

<RollOff>	float	
	Range:	0 to 1
	Increment:	0.001
	*RST:	0.1

Example: See Example"Configuring filter settings" on page 73.

Manual operation: See "Rolloff Factor" on page 38

[:SOURce<hw>]:BB:OFDM:FILTer:LENGth <FilterLength>

Sets the filter length.

Parameters:

<FilterLength>	integer	
	Range:	1 to 800
	*RST:	Deppends on the filter type

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Filter Length" on page 38

[:SOURce<hw>]:BB:OFDM:FILTer:SBATtenuation <StBAttenuation>

Sets the attenuation in the filter stop band.

Parameters:

<StBAttenuation>	float	
	Range:	10 to 120
	Increment:	0.001
	*RST:	60

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Stopband Attenuation" on page 38

[:SOURce<hw>]:BB:OFDM:FILTer:CUTTrans <CutTransResp>

Cuts the transient response of the filtering operation at the beginning and end of the signal.

Parameters:

<CutTransResp>	1 | ON | 0 | OFF	
	*RST:	0

Example: See Example"Configuring filter settings" on page 73.

Manual operation: See "Cut Transient Response" on page 39

[:SOURce<hw>]:BB:OFDM:FILTer:WINDowing <Windowing>

Sets the windowing method.

Parameters:

<Windowing>	NONE | HANNing | HAMMing *RST: HANNing

Example: See Example"Configuring filter settings" on page 73.

Manual operation: See "Windowing Method" on page 38

[:SOURce<hw>]:BB:OFDM:FILTer:UCATalog?

Queries the user filter files in the default directory. Only files with the file extension `*.dat` are listed.

Example: See Example"Generating a UFMC waveform" on page 79.

Usage: Query only

Manual operation: See "Load User Filter" on page 39

[:SOURce<hw>]:BB:OFDM:FILTer:USELection <UserSel>

Loads the selected file from the default or the specified directory. Loaded are files with extension `*.dat`.

Parameters:

<UserSel>	string Complete file path including file name and file extension

Example: See Example"Configuring filter settings" on page 73.

Manual operation: See "Load User Filter" on page 39

[:SOURce<hw>]:BB:OFDM:FILTer:ULENgth?

Queries the filter length.

Return values:

<UserFilterLen>	integer Range: 1 to 800 *RST: 0

Example: See Example"Configuring filter settings" on page 73.

Usage: Query only

Manual operation: See "User Filter Length" on page 39

4.4 Modulation commands

[:SOURce<hw>]:BB:OFDM:SUBCarriers?....................76
[:SOURce<hw>]:BB:OFDM:GFDM:DBSYmbols....................76
[:SOURce<hw>]:BB:OFDM:FOFDm:NSUBand....................76
[:SOURce<hw>]:BB:OFDM:UFMC:NSUBand....................77
[:SOURce<hw>]:BB:OFDM:UFMC:PREequal....................77

[:SOURce<hw>]:BB:OFDM:SUBCarriers?

Queries the number of subcarriers per subband.

Return values:

<SubcPerSubband> integer

Range: 1 to 16384
*RST: 1

Example: See Example"Generating a UFMC waveform" on page 79.

Usage: Query only

Manual operation: See "Subcarriers per Subband" on page 40

[:SOURce<hw>]:BB:OFDM:GFDM:DBSYmbols <GFDMDbSymbols>

Sets data block size in terms of symbols per data block.

The maximum size is the sequence length, see `[:SOURce<hw>]:BB:OFDM:SEQLength` on page 69.

Parameters:

<GFDMDbSymbols> integer

Range: 1 to depends on settings
*RST: 8

Example: `SOURce1:BB:OFDM:GFDM:DBSYmbols 8`

Manual operation: See "Datablock Size" on page 41

[:SOURce<hw>]:BB:OFDM:FOFDm:NSUBand <FofdmNSubands>

Sets the number of f-OFDM subbands.

Parameters:

<FofdmNSubands> integer

Range: 1 to 1500
*RST: 6

Example: `SOURce1:BB:OFDM:FOFDm:NSUBand 34`

Manual operation: See "Number of Subbands" on page 40

[:SOURce<hw>]:BB:OFDM:UFMC:NSUBand <NSubbands>

Sets the number of UFMC subbands.

Parameters:

<NSubbands> integer

Range: 1 to 1500
*RST: 6

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Number of Subbands" on page 40

[:SOURce<hw>]:BB:OFDM:UFMC:PREequal <UfmcPreEqual>

Applies a filter pre-equalization.

Parameters:

<UfmcPreEqual> 1 | ON | 0 | OFF

*RST: 0

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Subband Filter Pre-equalization" on page 40

4.5 User commands

[:SOURce<hw>]:BB:OFDM:USER<ch0>:DATA... 77
[:SOURce<hw>]:BB:OFDM:USER<ch0>:LIST..77
[:SOURce<hw>]:BB:OFDM:USER<ch0>:PATTern... 78
[:SOURce<hw>]:BB:OFDM:USER<ch0>:PWR..78

[:SOURce<hw>]:BB:OFDM:USER<ch0>:DATA <Datasource>

Sets the data source per user.

Parameters:

<Datasource> PN9 | PN11 | PN15 | PN16 | PN20 | PN21 | PN23 | PATTern | DLISt | ZERO | ONE

*RST: PN16

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Data Source" on page 42

[:SOURce<hw>]:BB:OFDM:USER<ch0>:LIST <DataList>

Selects an existing data list file from the default directory or from the specific directory.

Parameters:

<DataList> string

file name incl. file extension or complete file path

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Data Source" on page 42

[:SOURce<hw>]:BB:OFDM:USER<ch0>:PATTern <Pattern>, <BitCount>

Sets a bit pattern as a data source.

Parameters:

<Pattern> numeric

*RST: #H0

<BitCount> integer

Range: 1 to 64
*RST: 1

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Data Source" on page 42

[:SOURce<hw>]:BB:OFDM:USER<ch0>:PWR <Power>

Applies a power offset.

Parameters:

<Power> float

Range: -80 to 10
Increment: 1E-3
*RST: 0

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "ρ(dB)" on page 43

4.6 Allocation commands

Example: Generating a UFMC waveform

```
// *******************************************************************************
// Call the default settings.
// *******************************************************************************
*RST
// Presets the instrument.
// Alternatively, preset the OFDM baseband settings only.
SOURce1:BB:OFDM:PRESet
// Alternatively, preset only modulation parameters for the set modulation mode.
// For example, preset universal filtered multi-carrier modulation settings.
SOURce1:BB:OFDM:MODulation UFMC
SOURce1:BB:OFDM:MODPreset

// *******************************************************************************
// Configure physical settings of the modulation mode.
// *******************************************************************************
SOURce1:BB:OFDM:NSUBcarriers 512
SOURce1:BB:OFDM:NOCCupied 408
SOURce1:BB:OFDM:SCSPace 0.05
SOURce1:BB:OFDM:SEQLength 8
SOURce1:BB:OFDM:CPLength 10
SOURce1:BB:OFDM:RGUard?
// Response: "52"
SOURce1:BB:OFDM:LGUard?
// Response: "52"
SOURce1:BB:OFDM:BWOCcupied?
// Response: "20.4"
SOURce1:BB:OFDM:CSLength?
// Response: "0"
// No cyclic suffix configured.
SOURce1:BB:OFDM:DFTS:STATe?
// Response: "0"
// DFT-s-OFDM for data allocations is deactivated.
SOURce1:BB:OFDM:DCM?
// Response: "UTIL"
// Uses the DC subcarrier for all allocations.
SOURce1:BB:OFDM:SAMPling?
// Response: "25.6"
SOURce1:BB:OFDM:SRATe:VARiation?
// Response: "15360000"

// *******************************************************************************
// Configure filter settings of the modulation mode.
// *******************************************************************************
SOURce1:BB:OFDM:FILTer:TYPE DCH
SOURce1:BB:OFDM:FILTer:LENGth 74
SOURce1:BB:OFDM:FILTer:SBATtenuation 60
```

```
SOURce1:BB:OFDM:UFMC:NSUBand 34
SOURce1:BB:OFDM:SUBCarriers?
// Response: "12"
SOURce1:BB:OFDM:UFMC:PREequal?
// Response: "0"

// *******************************************************************************
// Configure user settings. Available users are always active.
// *******************************************************************************
SOURce1:BB:OFDM:USER0:DATA PN23
SOURce1:BB:OFDM:USER0:PWR 1
// Load the file 5g_datalist.dm_iqd from the default directory.
SOURce1:BB:OFDM:USER2:DATA DLIS
SOURce1:BB:OFDM:USER2:LIST "/var/user/5g_datalist.dm_iqd"
SOURce1:BB:OFDM:USER4:DATA PATT
SOURce1:BB:OFDM:USER4:PATTern #H1C4A9,17

// *******************************************************************************
// Confgure allocation settings
// *******************************************************************************
SOURce1:BB:OFDM:NALLoc 7
// Configure allocation 0 settings.
SOURce1:BB:OFDM:ALLoc0:CONTent?
// Response: "PRE"
SOURce1:BB:OFDM:ALLoc0:SYNO 2

// Confgure allocation 1 setting susing 256QAM modulation..
SOURce1:BB:OFDM:ALLoc1:CONTent?
// Response: "DATA"
SOURce1:BB:OFDM:ALLoc1:MODulation QAM256
SOURce1:BB:OFDM:ALLoc1:SCNO 100
SOURce1:BB:OFDM:ALLoc1:SCOFfset 2
SOURce1:BB:OFDM:ALLoc1:SYOFfset 2
SOURce1:BB:OFDM:ALLoc1:DATA USER0
SOURce1:BB:OFDM:ALLoc1:PHYSbits?
// Response: "4000"
SOURce1:BB:OFDM:ALLoc1:STATe 1

// Confgure allocation 2 settings.
SOURce1:BB:OFDM:ALLoc2:MODulation
SOURce1:BB:OFDM:ALLoc2:SCNO 200
SOURce1:BB:OFDM:ALLoc2:SYNO 2
SOURce1:BB:OFDM:ALLoc2:SCOFfset 150
SOURce1:BB:OFDM:ALLoc2:SYOFfset 2
SOURce1:BB:OFDM:ALLoc2:DATA USER3
// Confgure allocation 3 settings using sparse code multiple access modulation.
SOURce1:BB:OFDM:ALLoc3:MODulation SCMA
SOURce1:BB:OFDM:ALLoc3:SCNO 200
SOURce1:BB:OFDM:ALLoc3:SYNO 2
SOURce1:BB:OFDM:ALLoc3:SCOFfset 208
SOURce1:BB:OFDM:ALLoc3:SYOFfset 4
SOURce1:BB:OFDM:ALLoc3:PWR 3
```

```
// Confgure allocation 4 settings.
SOURce1:BB:OFDM:ALLoc4:CONFlict?
// Response: "1"
SOURce1:BB:OFDM:ALLoc4:SCNO 90
SOURce1:BB:OFDM:ALLoc4:SYNO 3
SOURce1:BB:OFDM:ALLoc4:SCOFfset 110
SOURce1:BB:OFDM:ALLoc4:SYOFfset 4
SOURce1:BB:OFDM:ALLoc4:DATA USER5
// Confgure allocation 5 settings using sparse code multiple access modulation.
SOURce1:BB:OFDM:ALLoc5:MODulation SCMA
SOURce1:BB:OFDM:ALLoc5:SCNO 252
SOURce1:BB:OFDM:ALLoc5:SCOFfset 90
SOURce1:BB:OFDM:ALLoc5:SYOFfset 7
SOURce1:BB:OFDM:ALLoc5:SCMA:CODebook?
// Response: "4"
SOURce1:BB:OFDM:ALLoc5:SCMA:NLAYers?
// Response: "6"
SOURce1:BB:OFDM:ALLoc5:SCMA:SPRead?
// Response: "4"
SOURce1:BB:OFDM:ALLoc5:SCMA:LAYer1:USER USER1
SOURce1:BB:OFDM:ALLoc5:SCMA:LAYer1:STATe 0
SOURce1:BB:OFDM:ALLoc5:SCMA:LAYer1:PWR?
// Response: "0"
SOURce1:BB:OFDM:ALLoc5:SCMA:LAYer2:STATe 0
SOURce1:BB:OFDM:ALLoc5:SCMA:LAYer4:STATe 0
SOURce1:BB:OFDM:ALLoc5:SCMA:LAYer0:STATe 0
SOURce1:BB:OFDM:ALLoc5:SCMA:LAYer3:STATe 0
SOURce1:BB:OFDM:ALLoc5:SCMA:LAYer5:STATe 0
// Response: "0"
SOURce1:BB:OFDM:ALLoc5:CONFlict?
// Response: "0"
// Confgure allocation 6 settings using a Zadoff-Chu sequence for modulation.
SOURce1:BB:OFDM:ALLoc6:MODulation ZAD
SOURce1:BB:OFDM:ALLoc6:SCNO 2
SOURce1:BB:OFDM:ALLoc6:SYNO 2
SOURce1:BB:OFDM:ALLoc6:SCOFfset 0
SOURce1:BB:OFDM:ALLoc6:SYOFfset 0
SOURce1:BB:OFDM:ALLoc6:DATA PN16
SOURce1:BB:OFDM:ALLoc6:ZAD:SNUMber 2
SOURce1:BB:OFDM:ALLoc6:ZAD:SLENgth 1
SOURce1:BB:OFDM:ALLoc6:ZAD:CYCShift 1

SOURce1:BB:OFDM:STATe 1
SOURce1:BB:OFDM:WAVeform:CREate "/var/user/5g_ufmc.wv"
```


- General commands....................82
- SCMA commands....................86
- Split pattern commands....................89
- Zadoff-Chu commands....................90
- Custom constellation commands....................92

4.6.1 General commands

[:SOURce<hw>]:BB:OFDM:NALLoc....82
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:MODulation....82
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:MOOR....83
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCNO....83
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SYNO....83
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCOFfset....84
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SYOFfset....84
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:PHYSbits?....84
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:DATA....84
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:LIST....85
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:PATTern....85
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CIQFile....85
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:PWR....85
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CONTent....86
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:STATe....86
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CONFlict?....86

[:SOURce<hw>]:BB:OFDM:NALLoc <NoOfAlloc>

Sets the number of scheduled allocations.

Parameters:

<NoOfAlloc> integer

Range: 0 to 500
*RST: 1

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Number of Allocations" on page 44

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:MODulation <BaseModType>

Sets the modulation type of an allocation.

Parameters:

<BaseModType> BPSK | QPSK | QAM16 | QAM64 | QAM256 | SCMA | CIQ | ZADoffchu | CUSConst

BPSK|QPSK
Binary/quaternary phase shift keying

QAM16|QAM64|QAM256
Quadrature amplitude modulation 16/64/256

SCMA
Sparse code multiple access

CIQ
Custom IQ data file, loaded with the command `[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CIQFile`.

ZADoffchu
Zadoff-Chu sequence

CUSConst
Custom constellation
*RST: QPSK

Example: See Example"Generating a UFMC waveform" on page 79.

Example: See Example"Configuring custom modulation settings" on page 92.

Manual operation: See "Constellation" on page 44

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:MOOR <ModOrder>

Sets/queries the modulation order of the allocation.

Setting requires custom constellation modulation, see `[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:MODulation` on page 82.

Parameters:
<ModOrder> integer
Range: 2 to 4096
*RST: 2

Example: See Example"Configuring custom modulation settings" on page 92.

Manual operation: See "Modulation Order" on page 45

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCNO <NoOfSubcarriers>

Sets the number of allocated subcarriers.

Parameters:
<NoOfSubcarriers> integer
Range: 1 to 13107
*RST: 1

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "No. SC" on page 45

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SYNO <NoOfSymbols>

Sets the allocation size as number of symbols.

Parameters:
<NoOfSymbols> integer
Range: 0 to 1000
*RST: 1

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "No. Sym." on page 45

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCOFfset <ScOffset>

Sets the start subcarrier of the selected allocation.

Parameters:

<ScOffset> integer

Range: 0 to 13106
*RST: 0

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Offs. SC" on page 45

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SYOFfset <SymOffset>

Sets the start symbol of the selected allocation.

Parameters:

<SymOffset> integer

Range: 0 to 999
*RST: 0

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Offs. Sym." on page 45

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:PHYSbits?

Queries the allocation size in bits.

Return values:

<PhysicalBits> integer

Example: See Example"Generating a UFMC waveform" on page 79.

Usage: Query only

Manual operation: See "Physical Bits" on page 45

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:DATA <Datasource>

Selects the data source for the selected allocation.

Parameters:

<Datasource> USER1 | USER2 | USER3 | USER4 | PN9 | PN11 | PN15 | PN16 | PN20 | PN21 | PN23 | PATTern | DLISt | ZERO | ONE | USER5 | USER0

*RST: PN16

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Data Source" on page 46

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:LIST <DataList>

Selects an existing data list file from the default directory or from the specific directory.

Parameters:

<DataList> string

file name incl. file extension or complete file path

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Data Source" on page 46

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:PATTern <Pattern>, <BitCount>

Sets a bit pattern as data source.

Parameters:

<Pattern> numeric

*RST: #H0

<BitCount> integer

Range: 1 to 64
*RST: 1

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Data Source" on page 46
See "Split Pattern" on page 48

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CIQFile <CustomIqFile>

Selects an existing file with custom I/Q data from the default directory or from the specific directory.

Parameters:

<CustomIqFile> string

Filename including file extension or complete file path

Example:

```
SOURce1:BB:OFDM:NALLoc 1
SOURce1:BB:OFDM:ALLoc0:MODulation CIQ
SOURce1:BB:OFDM:ALLoc0:CIQFile "/var/user/iq.iqw"
```

Manual operation: See "Data Source" on page 46

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:PWR <Power>

Applies a power offset to the allocation relative to the others.

Parameters:

<Power> float

Range: -80 to 10
Increment: 1E-3
*RST: 0

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "ρ(dB)" on page 46

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CONTent <ContentType>

Sets the content type.

Parameters:

<ContentType> DATA | PREamble | PILot | REServed

DATA
Default value for FBMC and GFDM modulations.

PREamble
Default value for the first allocation of the UFMC modulation.

DATA|PILot|REServed
Selects the content type for f-OFDM/OFDM modulations.

*RST: DATA

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Content Type" on page 47

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:STATe <State>

Enables the allocation.

Parameters:

<State> 1 | ON | 0 | OFF

*RST: 0

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "State" on page 48

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CONFlict?

Returns `1`, if allocations overlap.

Return values:

<Conflict> 1 | ON | 0 | OFF

Example: See Example"Generating a UFMC waveform" on page 79.

Usage: Query only

Manual operation: See "Conflict" on page 48

4.6.2 SCMA commands

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCMA:NLAYers?....................87
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCMA:SPRead?....................87
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCMA:CODebook?....................87

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCMA:LAYer<st0>:PWR?....................................87
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCMA:LAYer<st0>:STATe....................................88
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCMA:LAYer<st0>:USER....................................88

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCMA:NLAYers?

Queries the number of layers.

Return values:

<NoOfLayers> integer

Range: 0 to 6
*RST: 6

Example: See Example"Generating a UFMC waveform" on page 79.

Usage: Query only

Manual operation: See "Number of Layers J" on page 51

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCMA:SPRead?

Queries the spreading factor.

Return values:

<SpreadFac> integer

Range: 0 to 4
*RST: 4

Example: See Example"Generating a UFMC waveform" on page 79.

Usage: Query only

Manual operation: See "Spreading Factor K" on page 51

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCMA:CODebook?

Queries the codebook size.

Return values:

<Codebook> integer

Range: 0 to 4
*RST: 4

Example: See Example"Generating a UFMC waveform" on page 79.

Usage: Query only

Manual operation: See "Codebook Size M" on page 51

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCMA:LAYer<st0>:PWR?

Applies a power offset to the selected layer relative to the others.

Return values:

<Power> float

Range: -80 to 10
Increment: 1E-3
*RST: 0

Example: See Example"Generating a UFMC waveform" on page 79.

Usage: Query only

Manual operation: See "ρ(dB)" on page 51

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCMA:LAYer<st0>:STATe <State>

Enables the layer (codebook).

Parameters:

<State> 1 | ON | 0 | OFF

*RST: 0

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "State" on page 51

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCMA:LAYer<st0>:USER <ScmaLayerUser>

Maps the users to the layers.

Parameters:

<ScmaLayerUser> USER0 | USER1 | USER2 | USER3 | USER4 | USER5

*RST: USER0

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "User" on page 51

4.6.3 Split pattern commands

Example: Configuring split pattern settings

```
// Set split pattern subcarrier spacing (SCS) settings for alloction 0.
SOURce1:BB:OFDM:ALLoc0:SPLT:SCS:SIZE 53
// Query SCS step.
SOURce1:BB:OFDM:ALLoc0:SPLT:SCS:STEP?
// Response: "53"
// Set split pattern symbol settings for alloction 0.
SOURce1:BB:OFDM:ALLoc0:SPLT:SYM:SIZE 2
// Query SCS step.
SOURce1:BB:OFDM:ALLoc0:SPLT:SCS:STEP?
// Response: "2"
// Activate split pattern settings for alloction 0.
SOURce1:OFDM:ALLoc0:SPLT:STATe 1
```

Commands

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SPLT:STATe....................89
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SPLT:SCS:SIZE....................89
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SPLT:SCS:STEP....................90
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SPLT:SYM:SIZE....................90
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SPLT:SYM:STEP....................90

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SPLT:STATe <SplitPatState>

Activates split pattern settings for the selected allocation.

Parameters:

<SplitPatState> 1 | ON | 0 | OFF

*RST: 0

Example: See Example"Configuring split pattern settings" on page 89.

Manual operation: See "Split Pattern" on page 49

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SPLT:SCS:SIZE <SplitPatScsSize>

Sets the subcarrier spacing (SCS) size.

The maximum SCS size equals the number of subcarriers of the selected allocation, see `[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCNO` on page 83.

Parameters:

<SplitPatScsSize> integer

Range: 1 to 13107
*RST: 1

Example: See Example"Configuring split pattern settings" on page 89.

Manual operation: See "SCS Size" on page 49

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SPLT:SCS:STEP <SplitPatScsStep>

Sets/queries the subcarrier spacing (SCS) step.

Setting requires SCS sizes smaller than the set number of subcarriers of the selected allocation, see `[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCNO` on page 83.

Parameters:

<SplitPatScsStep> integer

Range: 1 to 13107
*RST: 1

Example: See Example"Configuring split pattern settings" on page 89.

Manual operation: See "SCS Step" on page 49

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SPLT:SYM:SIZE <SplitPatSymSize>

Sets the symbol size.

Parameters:

<SplitPatSymSize> integer

Range: 1 to 1000
*RST: 1

Example: See Example"Configuring split pattern settings" on page 89.

Manual operation: See "Symbol Size" on page 49

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SPLT:SYM:STEP <SplitPatSymStep>

Sets/queries the symbol step.

Setting requires symbol sizes smaller than the number of symbols of the selected allocation.

Parameters:

<SplitPatSymStep> integer

Range: 1 to 1000
*RST: 1

Example: See Example"Configuring split pattern settings" on page 89.

Manual operation: See "Symbol Step" on page 49

4.6.4 Zadoff-Chu commands

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:ZAD:CYCShift......91
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:ZAD:SLEN...... 91
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:ZAD:SNUMber......91

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:ZAD:CYCShift <CyclicShift>

Sets the cyclic shift of the Zadoff-Chu sequence.

The maximum number of cyclic shifts is the sequence length minus 1.

Parameters:

<CyclicShift> integer

Range: 0 to 1023
*RST: 0

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Cyclic Shift" on page 52

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:ZAD:SLEN <SeqLength>

Sets the sequence length of the Zadoff-Chu sequence.

Parameters:

<SeqLength> integer

Range: 2 to 13107
*RST: 2

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Sequence Length" on page 52

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:ZAD:SNUMber <SeqNumber>

Sets the sequence number within the Zadoff-Chu sequence.

The maximum sequence number is the sequence length minus 1.

Parameters:

<SeqNumber> integer

Range: 1 to 13106
*RST: 1

Example: See Example"Generating a UFMC waveform" on page 79.

Manual operation: See "Sequence Number" on page 52

4.6.5 Custom constellation commands

Example: Configuring custom modulation settings

```
// Set custom constellation for alloction 0.
SOURce1:BB:OFDM:ALLoc0:MOD CUSConst
// Define modulation order and constellation points.
// For example, define a typical BPSK constellation.
// Set modulation order of 2.
SOURce1:BB:OFDM:ALLoc0:MOOR 2
// Define real and imaginary part of the first constellation point.
SOURce1:BB:OFDM:ALLoc0:CONPoint0:REAL 1
SOURce1:BB:OFDM:ALLoc0:CONPoint0:IMAG 0
// Define real and imaginary part of the second constellation point.
SOURce1:BB:OFDM:ALLoc0:CONPoint1:REAL -1
SOURce1:BB:OFDM:ALLoc0:CONPoint1:IMAG 0
// Optionally, query constellation points in cylindical coordinates.
SOURce1:BB:OFDM:ALLoc0:CONPoint0:MAGNitude?
// Response: "1.414"
// The magnitude equals the square root of 2.
SOURce1:BB:OFDM:ALLoc0:CONPoint0:PHASe?
// Response: "45"
// The phase is 45 degrees.
SOURce1:BB:OFDM:ALLoc0:CONPoint1:MAGNitude?
// Response: "1.414"
// The magnitude equals the square root of 2.
SOURce1:BB:OFDM:ALLoc0:CONPoint1:PHASe?
// Response: "225"
// The phase is 225 degrees.
```

Commands

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CONPoint<st0>:IMAG.. 92
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CONPoint<st0>:MAGN.. 93
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CONPoint<st0>:PHASe.. 93
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CONPoint<st0>:REAL.. 93

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CONPoint<st0>:IMAG <CustConstImag>

Sets the imaginary part of the constellation point of the selected allocation.

The imaginary part equals the y-axis value in a cartesian coordinate system.

Parameters:

<CustConstImag> float

Range: -100 to 100
Increment: 0.001
*RST: 0

Example: See Example"Configuring custom modulation settings" on page 92.

Manual operation: See "Constellation coordinates table" on page 53

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CONPoint<st0>:MAGN <CustConstMagn>

Sets the magnitude of the constellation point of the selected allocation.

The magnitude value applies for a cylindrical coordinate system.

Parameters:

<CustConstMagn> float

Range: 0 to 100
Increment: 0.001
*RST: 0

Example: See Example"Configuring custom modulation settings" on page 92.

Manual operation: See "Constellation coordinates table" on page 53

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CONPoint<st0>:PHASe <CustConstPhase>

Parameters:

<CustConstPhase> float

Range: 0 to 360
Increment: 0.1
*RST: 0

Manual operation: See "Constellation coordinates table" on page 53

[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CONPoint<st0>:REAL <CustConstReal>

Sets the real part of the constellation point of the selected allocation.

The real part equals the x-axis value in a cartesian coordinate system.

Parameters:

<CustConstReal> float

Range: -100 to 100
Increment: 0.001
*RST: 0

Example: See Example"Configuring custom modulation settings" on page 92.

Manual operation: See "Constellation coordinates table" on page 53

4.7 Trigger commands

Example: Configuring trigger signals

```
SOURce1:BB:OFDM:TRIGger:SEQuence SINGle
SOURce1:BB:OFDM:TRIGger:SLENgth 200
// Outputs the first 200 samples of the current waveform after the trigger event.
SOURce1:BB:OFDM:TRIGger:SEQuence ARETrigger
SOURce1:BB:OFDM:TRIGger:SOURce EGT1
// Uses the external trigger signal from the USER connector.
SOURce1:BB:OFDM:TRIGger:EXTernal:SYNChronize:OUTPut ON
SOURce1:BB:OFDM:TRIGger:EXTernal:DELay 200
SOURce1:BB:OFDM:TRIGger:EXTernal:INHibit 100

SOURce1:BB:OFDM:TRIGger:SEQuence AAUTo
SOURce1:BB:OFDM:TRIGger:SOURce INTernal
SOURce1:BB:OFDM:STATe 1
SOURce1:BB:OFDM:TRIGger:EXEC
```

Example: Specifying delay and inhibit values in time units

```
SOURce1:BB:OFDM:CLOCk 1000000
SOURce1:BB:OFDM:TRIGger:SEQuence AAUT
SOURce1:BB:OFDM:TRIGger:SOURce EGT1
SOURce1:BB:OFDM:TRIGger:DELay:UNIT SAMP
SOURce1:BB:OFDM:TRIGger:EXTernal:DELay 100
SOURce1:BB:OFDM:TRIGger:EXTernal:RDELay?
// Response in seconds: "100"

SOURce1:BB:OFDM:TRIGger:DELay:UNIT TIME
SOURce1:BB:OFDM:TRIGger:EXTernal:TDELay 0.00001
SOURce1:BB:OFDM:TRIGger:EXTernal:RDELay?
// Response in seconds: "0.00001"
// Corresponds to 10 µs.
SOURce1:BB:OFDM:TRIGger:DELay:UNIT SAMP
SOURce1:BB:OFDM:TRIGger:EXTernal:DELay 10
```

[:SOURce<hw>]:BB:OFDM[:TRIGger]:SEQuence....95
[:SOURce<hw>]:BB:OFDM:TRIGger:SOURce....95
[:SOURce<hw>]:BB:OFDM:TRIGger:RMODe?....95
[:SOURce<hw>]:BB:OFDM:TRIGger:TIME:DATE....96
[:SOURce<hw>]:BB:OFDM:TRIGger:TIME:TIME....96
[:SOURce<hw>]:BB:OFDM:TRIGger:TIME[:STATe]....97
[:SOURce<hw>]:BB:OFDM:TRIGger:SLENgth....97
[:SOURce<hw>]:BB:OFDM:TRIGger:SLUNit....97
[:SOURce<hw>]:BB:OFDM:TRIGger:EXECute....97
[:SOURce<hw>]:BB:OFDM:TRIGger:ARM:EXECute....98
[:SOURce<hw>]:BB:OFDM:TRIGger:EXTernal:SYNChronize:OUTPut....98
[:SOURce<hw>]:BB:OFDM:TRIGger:DELay:UNIT....98
[:SOURce<hw>]:BB:OFDM:TRIGger[:EXTernal]:DELay....98

[:SOURce<hw>]:BB:OFDM:TRIGger:EXTernal:TDELay..99
[:SOURce<hw>]:BB:OFDM:TRIGger:EXTernal:RDELay?..99
[:SOURce<hw>]:BB:OFDM:TRIGger[:EXTernal]:INHibit...99

[:SOURce<hw>]:BB:OFDM[:TRIGger]:SEQuence <TrigMode>

Sets the trigger mode.

Parameters:

<TrigMode> AUTO | RETRigger | AAUTo | ARETrigger | SINGle

*RST: AUTO

Example: See Example"Configuring trigger signals" on page 94.

Manual operation: See "Mode" on page 56

[:SOURce<hw>]:BB:OFDM:TRIGger:SOURce <TrigSource>

Selects the trigger signal source and determines the way the triggering is executed. Provided are:

- Internal triggering by a command (`INTernal`)
- External trigger signal via one of the local or global connectors
  - `EGT1|EGT2`: External global trigger
  - `EGC1|EGC2`: External global clock
- In primary-secondary instrument mode, the external baseband synchronization signal (`BBSY`)
- `OBASeband|BEXTernal|EXTernal`: Setting only
  Provided only for backward compatibility with other Rohde & Schwarz signal generators.
  The R&S SMM100A accepts these values and maps them automatically as follows:
  `EXTernal = EGT1`, `BEXTernal = EGT2`, `OBASeband = INTA`

Parameters:

<TrigSource> INTernal|EGT1|EGT2|EGC1|EGC2|EXTernal|BBSY

*RST: INTernal

Example: See Example"Configuring trigger signals" on page 94.

Manual operation: See "Source" on page 58

[:SOURce<hw>]:BB:OFDM:TRIGger:RMODe?

Queries the status of waveform output.

Return values:

<TrigRunMode> STOP | RUN

*RST: STOP

Example: See Example"Configuring trigger signals" on page 94.

Usage: Query only

Manual operation: See "Running/Stopped" on page 57

[:SOURce<hw>]:BB:OFDM:TRIGger:TIME:DATE <Year>, <Month>, <Day>

Sets the date for a time-based trigger signal. For trigger modes single or armed auto, you can activate triggering at this date via the following command:

`SOURce<hw>:BB:<DigStd>:TRIGger:TIME:STATe`

`<DigStd>` is the mnemonic for the digital standard, for example, `ARB`. Time-based triggering behaves analogously for all digital standards that support this feature.

Parameters:

<Year> integer

Range: 1980 to 9999

<Month> integer

Range: 1 to 12

<Day> integer

Range: 1 to 31

Example: See example "Configure a time-based trigger signal" in the subchapter "Trigger Commands" of the chapter "SOURce:BB:ARB subsystem" in the R&S SMM100A user manual.

Manual operation: See "Trigger Time" on page 57

[:SOURce<hw>]:BB:OFDM:TRIGger:TIME:TIME <Hour>, <Minute>, <Second>

Sets the time for a time-based trigger signal. For trigger modes single or armed auto, you can activate triggering at this time via the following command:

`SOURce<hw>:BB:<DigStd>:TRIGger:TIME:STATe`

`<DigStd>` is the mnemonic for the digital standard, for example, `ARB`. Time-based triggering behaves analogously for all digital standards that support this feature.

Parameters:

<Hour> integer

Range: 0 to 23

<Minute> integer

Range: 0 to 59

<Second> integer

Range: 0 to 59

Example: See example "Configure a time-based trigger signal" in the subchapter "Trigger Commands" of the chapter "SOURce:BB:ARB subsystem" in the R&S SMM100A user manual.

Manual operation: See "Trigger Time" on page 57

[:SOURce<hw>]:BB:OFDM:TRIGger:TIME[:STATe] <State>

Activates time-based triggering with a fixed time reference. If activated, the R&S SMM100A triggers signal generation when its operating system time matches a specified time.

Specify the trigger date and trigger time with the following commands:

`SOURce<hw>:BB:<DigStd>:TRIGger:TIME:DATE`

`SOURce<hw>:BB:<DigStd>:TRIGger:TIME:TIME`

`<DigStd>` is the mnemonic for the digital standard, for example, `ARB`. Time-based triggering behaves analogously for all digital standards that support this feature.

Parameters:

<State> 1 | ON | 0 | OFF

*RST: 0

Example: See example "Configure a time-based trigger signal" in the subchapter "Trigger Commands" of the chapter "SOURce:BB:ARB subsystem" in the R&S SMM100A user manual.

Manual operation: See "Time Based Trigger" on page 57

[:SOURce<hw>]:BB:OFDM:TRIGger:SLENgth <TrigSeqLen>

Defines the length of the signal sequence to be output in the `SINGle` trigger mode.

Parameters:

<TrigSeqLen> integer

Range: 1 to dynamic
*RST: 1

Example: See Example"Configuring trigger signals" on page 94.

Manual operation: See "Signal Duration" on page 57

[:SOURce<hw>]:BB:OFDM:TRIGger:SLUNit <TrigSeqLenUnit>

Defines the unit for the entry of the length of the signal sequence to be output in the `SINGle` trigger mode.

Parameters:

<TrigSeqLenUnit> SEQuence | SAMPle

*RST: SEQuence

Example: See Example"Configuring trigger signals" on page 94.

Manual operation: See "Signal Duration Unit" on page 57

[:SOURce<hw>]:BB:OFDM:TRIGger:EXECute

Executes an internal trigger event.

Example: See Example"Configuring trigger signals" on page 94.

Usage: Event

Manual operation: See "Execute Trigger" on page 58

[:SOURce<hw>]:BB:OFDM:TRIGger:ARM:EXECute

Stops (arms) waveform output.

Example: See Example"Configuring trigger signals" on page 94.

Usage: Event

Manual operation: See "Arm" on page 58

[:SOURce<hw>]:BB:OFDM:TRIGger:EXTernal:SYNChronize:OUTPut <TrigSyncOutpSta>

Enables signal output synchronous to the trigger event.

Parameters:

<TrigSyncOutpSta> 1 | ON | 0 | OFF

*RST: 1

Example: See Example"Configuring trigger signals" on page 94.

Manual operation: See "Sync. Output to External Trigger/Sync. Output to Trigger" on page 58

[:SOURce<hw>]:BB:OFDM:TRIGger:DELay:UNIT <TrigDelUnit>

Determines the unit that the trigger delay is expressed in.

Parameters:

<TrigDelUnit> SAMPle | TIME

*RST: SAMPle

Example: See Example"Specifying delay and inhibit values in time units" on page 94.

Manual operation: See "(External) Delay Unit" on page 59

[:SOURce<hw>]:BB:OFDM:TRIGger[:EXTernal]:DELay <TrigExtDelay>

Specifies the trigger delay.

Parameters:

<TrigExtDelay> float

Range: 0 to 2147483647
Increment: 0.01
*RST: 0

Example: See Example"Configuring trigger signals" on page 94.

Manual operation: See "(Specified) External Delay/(Specified) Trigger Delay" on page 60

[:SOURce<hw>]:BB:OFDM:TRIGger:EXTernal:TDELay <TrigExtTimeDel>

Specifies the trigger delay for external triggering. The value affects all external trigger signals.

Parameters:

<TrigExtTimeDel> float

Range: 0 to 688
Increment: 250E-12
*RST: 0
Default unit: s

Example: See Example"Specifying delay and inhibit values in time units" on page 94.

Manual operation: See "(Specified) External Delay/(Specified) Trigger Delay" on page 60

[:SOURce<hw>]:BB:OFDM:TRIGger:EXTernal:RDELay?

Queries the time (in seconds) an external trigger event is delayed for.

Return values:

<ResExtDelaySec> float

Range: 0 to 688
Increment: 250E-12
*RST: 0

Example: See Example"Specifying delay and inhibit values in time units" on page 94.

Usage: Query only

Manual operation: See "Actual Trigger Delay/Actual External Delay" on page 60

[:SOURce<hw>]:BB:OFDM:TRIGger[:EXTernal]:INHibit <TrigExtInhibit>

Specifies the number of samples by which a restart is to be inhibited following an external trigger event.

Parameters:

<TrigExtInhibit> integer

Range: 0 to dynamic
*RST: 0

Example: See Example"Configuring trigger signals" on page 94.

Manual operation: See "External Inhibit/Trigger Inhibit" on page 59

4.8 Marker commands

Example: Activating a marker 2 signal

```
SOURce1:BB:OFDM:TRIGger:OUTPut2:MODE?
// Response: "RESTart"
SOURce1:BB:OFDM:TRIGger:OUTPut2:FOFFset 10
SOURce1:BB:OFDM:TRIGger:OUTPut2:ROFFset 20

SOURce1:BB:OFDM:TRIGger:OUTPut2:DELay?
// Response in samples: "10"
```

[:SOURce<hw>]:BB:OFDM:TRIGger:OUTPut<ch>:MODE.. 100
[:SOURce<hw>]:BB:OFDM:TRIGger:OUTPut<ch>:ROFFset.. 100
[:SOURce<hw>]:BB:OFDM:TRIGger:OUTPut<ch>:FOFFset.. 100
[:SOURce<hw>]:BB:OFDM:TRIGger:OUTPut<ch>:DELay.. 100

[:SOURce<hw>]:BB:OFDM:TRIGger:OUTPut<ch>:MODE <MarkMode>

Defines the signal for the selected marker output.

Parameters:

<MarkMode> RESTart

*RST: RESTart

Example: See Example"Activating a marker 2 signal" on page 100.

Manual operation: See "Mode" on page 61

[:SOURce<hw>]:BB:OFDM:TRIGger:OUTPut<ch>:ROFFset <MarkRiseOffs>
[:SOURce<hw>]:BB:OFDM:TRIGger:OUTPut<ch>:FOFFset <MarkFallOffs>

Shifts the rising or falling ramp of the marker by the selected number of samples.

Parameters:

<MarkFallOffs> integer

Range: -640000 to 640000
*RST: 0

Example: See Example"Activating a marker 2 signal" on page 100.

Manual operation: See "Rise Offset/Fall Offset" on page 61

[:SOURce<hw>]:BB:OFDM:TRIGger:OUTPut<ch>:DELay <MarkDelay>

Defines the delay between the signal on the marker outputs and the start of the signals.

Parameters:

<MarkDelay> float

Range: 0 to 16777215
Increment: 1
*RST: 0
Default unit: Samples

Example: See Example"Activating a marker 2 signal" on page 100.

Manual operation: See "Delay" on page 61

4.9 Clock commands

Example: Configuring clock settings

```
SOURce1:BB:OFDM:CLOCk:SOURce ELCL
SOURce1:BB:OFDM:CLOCk:MODE SAMP
CLOCk:INPUt:FREQuency?
```

[:SOURce<hw>]:BB:OFDM:CLOCk:SOURce..101
[:SOURce<hw>]:BB:OFDM:CLOCk:MODE...101

[:SOURce<hw>]:BB:OFDM:CLOCk:SOURce <ClockSour>

Selects the clock source:

- `INTernal`: Internal clock reference
- `ELCLock`: External local clock
- `EXTernal = ELCLock`: Setting only
  Provided for backward compatibility with other Rohde & Schwarz signal generators

Parameters:

<ClockSour> INTernal

*RST: INTernal

Example: See Example"Configuring clock settings" on page 101.

Manual operation: See "Clock Source" on page 62

[:SOURce<hw>]:BB:OFDM:CLOCk:MODE <ClockMode>

Sets the type of externally supplied clock.

Parameters:

<ClockMode> SAMPle

*RST: SAMPle

Example: See Example"Configuring clock settings" on page 101.

Annex

A XML settings file

You can use the created `*.xml` file for OFDM signal analysis. See "Export path for XML settings ..." on page 29. Use the file for measurements with Rohde & Schwarz signal analyzer, for example R&S®VSE-K96.

Example: Default "Exported_K114_settings_K96.xml" file

The example shows the structure of the default file `Exported_K114_settings_K96.xml`.

```
<?xml version="1.0" encoding="utf-8"?>
<FSK96ConfigurationFile>
  <GeneralParameters>
    <Name>OFDM_16MHzBW_312kHzSpacing</Name>
    <FFTSize>64</FFTSize>
    <NofSymbols>10</NofSymbols>
    <CyclicDelayDiversity>0</CyclicDelayDiversity>
    <CyclicPrefixLength>16</CyclicPrefixLength>
    <StartCarrierIndex>0</StartCarrierIndex>
    <Description>Automatically exported R&S SMM100A-K114 settings to K96 system
     configuration file.</Description>
  </GeneralParameters>
  <Preamble>
    <BlockLength>0</BlockLength>
    <FrameOffset>0</FrameOffset>
  </Preamble>
  <Constellations>
    <Constellation>
      <ID>0</ID>
      <Name>Zero</Name>
      <HumanReadableName>Zero</HumanReadableName>
      <ScalingFactor>1.0</ScalingFactor>
      <AllocationType>Zero</AllocationType>
      <IQSymbols>
        <IQ>
          <Re>0.000000</Re>
          <Im>0.000000</Im>
        </IQ>
      </IQSymbols>
    </Constellation>
    <Constellation>
      <ID>1</ID>
      <Name>DontCare</Name>
      <HumanReadableName>DontCare</HumanReadableName>
      <ScalingFactor>1.0</ScalingFactor>
```

```
  <AllocationType>DontCare</AllocationType>
</Constellation>
<Constellation>
  <ID>2</ID>
  <Name>PilotConstellation</Name>
  <HumanReadableName>PilotConstellation</HumanReadableName>
  <ScalingFactor>1</ScalingFactor>
  <AllocationType>PilotConstellation</AllocationType>
  <IQSymbols>
    <IQ>
      <Re>-0.707107</Re>
      <Im>-0.707107</Im>
    </IQ>
    <IQ>
      <Re>-0.707107</Re>
      <Im>0.707107</Im>
    </IQ>
    <IQ>
      <Re>0.707107</Re>
      <Im>-0.707107</Im>
    </IQ>
    <IQ>
      <Re>0.707107</Re>
      <Im>0.707107</Im>
    </IQ>
  </IQSymbols>
</Constellation>
<Constellation>
  <ID>3</ID>
  <Name>QAM64</Name>
  <HumanReadableName>QAM64</HumanReadableName>
  <ScalingFactor>1</ScalingFactor>
  <AllocationType>DataConstellation</AllocationType>
  <IQSymbols>
    <IQ>
      <Re>-1.080123</Re>
      <Im>-1.080123</Im>
    </IQ>
    <!---> 62 I/Q pairs neglected (64 QAM) </!--->
    <IQ>
      <Re>1.080123</Re>
      <Im>1.080123</Im>
    </IQ>
  </IQSymbols>
</Constellation>
<Constellation>
  <ID>4</ID>
  <Name>PilotConstellation</Name>
  <HumanReadableName>PilotConstellation</HumanReadableName>
  <ScalingFactor>1</ScalingFactor>
```

```
        <AllocationType>PilotConstellation</AllocationType>
        <IQSymbols>
          <IQ>
            <Re>-1.000000</Re>
            <Im>0.000000</Im>
          </IQ>
          <IQ>
            <Re>1.000000</Re>
            <Im>0.000000</Im>
          </IQ>
        </IQSymbols>
      </Constellation>
    </Constellations>
    <Allocation>
      <Matrix>AQEBAQECAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgIC
AgICAgICAgEBAQEBAQEBAQEBAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgIC
AgICAgICAgICAgIBAQEBAQEBAQEBAQMDAwMDAwMDAwMDAwMDAwMDAwMDAwMDAwMDAwMD
AwMDAwMDAwMDAwMDAwMDAQEBAQEBAQEBAQEDAwMDAwMDAwMDAwMDAwMDAwMDAwMDAwMD
AwMDAwMDAwMDAwMDAwMDAwMDAwEBAQEBAQEBAQEBAwMDAwMDAwMDAwMDAwMDAwMDAwMD
AwMDAwMDAwMDAwMDAwMDAwMDAwMBAQEBAQEBAQEBAQMDAwMDAwMDAwMDAwMDAwMDAwMD
AwMDAwMDAwMDAwMDAwMDAwMDAwMDAwMDAQEBAQEBAQEBAQEDAwMDAwMDAwMDAwMDAwMD
AwMDAwMDAwMDAwMDAwMDAwMDAwMDAwMDAwMDAwEBAQEBAQEBAQEBAwMDAwMDAwMDAwMD
AwMDAwMDAwMDAwMDAwMDAwMDAwMDAwMDAwMDAwMDAwMBAQEBAQEBAQEBAQQEBAQEBAQEBAQE
BAQEBAQEBAQEBAQEBAQEBAQEBAQEBAQEBAQEBAQEBAQEBAQEBAQEAQEBAQEBAQEBAQEEBAQEBAQEBAQE
BAQEBAQEBAQEBAQEBAQEBAQEBAQEBAQEBAQEBAQEBAQEBAQEBAQEBAEBAQEBAQ==</Matrix>
    </Allocation>
    <PilotInformation>
      <PilotSymbolIdxArray>AQADAAMAAwADAAMAAwADAAEAAwADAAMAAwACAAIAAQABAAMAAwABAAM
AAQABAAMAAAACAAAAAQAAAAIAAgABAAEAAwABAAIAAAABAAEAAgAAAAIAAAADAAMAAAABAAAAAAAADAAE
AAQACAAAAAwAAAAAAAAAAAAAEAAgACAAAAAwADAAAAAAABAAIAAwABAAEAAAAAAAAAAAwACAAEAAQACAAI
AAQADAAAAAQABAAEAAAABAAMAAgACAAMAAQABAAIAAwACAAAAAgAAAAEAAgABAAMAAAAAAAAEAAQABAAE
AAQABAAEAAQABAAEAAQABAAEAAQABAAAAAQABAAEAAQABAAEAAQABAAEAAQAAAAEAAAAAAAAEAAAABAAE
AAQABAAEAAAABAAEAAQAAAAEAAAABAAEAAQAAAAAAAQAAAAAAAAAAAAAEAAAAAAAEAAAABAAAAAAABAAA
AAQABAAEAAAABAAEAAAAAAAAAAAAAABAAAAAQABAAAAAAAAAAAEAAAAAAAAAAQABAAEAAQAAAAAAAAAABAAA
AAAAAAAAAQABAAAAAQAAAAEAAQAAAA==</PilotSymbolIdxArray>
    </PilotInformation>
  </FSK96ConfigurationFile>
```

Glossary: Terms and abbreviations

A

ARB: Arbitrary Waveform Generator

C

CoMP: Coordinated multipoint

F

f-OFDM: Filtered OFDM
Synonyms: SF-OFDM, UF-OFDM, RB-F-OFDM

FBMC: Filter-Bank Multi-carrier

FFT: Fast Fourier Transformation

G

GFDM: Generalized Frequency Division Multiplexing

I

IFFT: Inverse Fast Fourier Transformation

N

NOMA: Non-Orthogonal Multiple Access

O

OFDM: Orthogonal Frequency-Division Multiplexing

OQAM: Offset QAM

Q

QAM: Quadrature amplitude modulation

R

RB-F-OFDM: Resource block based filtered OFDM
see f-OFDM

Resource block (UFMC): Subband (UFMC)

S

SCMA: Sparse code multiple access

SF-OFDM: Spectrum Filtered-OFDM
see f-OFDM

SMT FBMC: Staggered modulated multitone filter bank

Subband (UFMC): In the context of the UFMC modulation, the term subband describes the smallest amount of resources that can be allocated to a user.
Synonyms: Resource block, Subcarrier

Subcarrier (UFMC): Subband (UFMC)

U

UF-OFDM: Universal Filtered-OFDM
see f-OFDM

UFMC: Universal Filtered Multi-Carrier

Universal Filtered OFDM (UF-OFDM): UFMC

Glossary: Specifications, references and further information

Symbols

[1]: Michailow, N.; Gaspar, I.; Krone, S.; Lentmaier, M.; Fettweis, G.
"Generalized Frequency Division Multiplexing: Analysis of an Alternative Multi-Carrier Technique for Next Generation Cellular Systems", Aug. 2012

[2]: Schaich, F.; Wild, T.; Chen, Y.
“Waveform contenders for 5G - suitability for short packet and low latency transmissions,” VTC Spring, May 2014.

[3]: Viholainen, A.; Bellanger, M.; Huchard, M.
"PHYDYAS – PHYsical layer for DYnamic AccesS and cognitive radio", Report D5.1, Jan. 2009

5GNOW: Project 5th Generation Non-orthogonal Waveforms for Asynchronous Signaling
http://www.5gnow.eu

5GNOW D3.x: 5G Waveform Candidate Selection, Version D3.2
Final 5GNOW Transceiver and frame structure concept, Version D3.3

List of commands

[:SOURce<hw>]:BB:OFDM:ACPLength...70
[:SOURce<hw>]:BB:OFDM:ACPSymbols...70
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CIQFile...85
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CONFlict?...86
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CONPoint<st0>:IMAG...92
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CONPoint<st0>:MAGN...93
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CONPoint<st0>:PHASe...93
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CONPoint<st0>:REAL...93
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:CONTent...86
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:DATA...84
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:LIST...85
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:MODulation...82
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:MOOR...83
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:PATTern...85
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:PHYSbits?...84
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:PWR...85
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCMA:CODebook?...87
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCMA:LAYer<st0>:PWR?...87
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCMA:LAYer<st0>:STATe...88
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCMA:LAYer<st0>:USER...88
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCMA:NLAYers?...87
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCMA:SPRead?...87
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCNO...83
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SCOFfset...84
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SPLT:SCS:SIZE...89
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SPLT:SCS:STEP...90
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SPLT:STATe...89
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SPLT:SYM:SIZE...90
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SPLT:SYM:STEP...90
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:STATe...86
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SYNO...83
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:SYOFfset...84
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:ZAD:CYCShift...91
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:ZAD:SLEN...91
[:SOURce<hw>]:BB:OFDM:ALLoc<ch0>:ZAD:SNUMber...91
[:SOURce<hw>]:BB:OFDM:BWOCcupied?...72
[:SOURce<hw>]:BB:OFDM:CLOCk:MODE...101
[:SOURce<hw>]:BB:OFDM:CLOCk:SOURce...101
[:SOURce<hw>]:BB:OFDM:CPLength...69
[:SOURce<hw>]:BB:OFDM:CPSYmbols...70
[:SOURce<hw>]:BB:OFDM:CSLength...71
[:SOURce<hw>]:BB:OFDM:DCMode...71
[:SOURce<hw>]:BB:OFDM:DFTS:STATe...71
[:SOURce<hw>]:BB:OFDM:FILTer:CUTTrans...74
[:SOURce<hw>]:BB:OFDM:FILTer:LENGth...74
[:SOURce<hw>]:BB:OFDM:FILTer:ROLLoff...74
[:SOURce<hw>]:BB:OFDM:FILTer:SBATtenuation...74

[:SOURce<hw>]:BB:OFDM:FILTer:TYPE....73
[:SOURce<hw>]:BB:OFDM:FILTer:UCATalog?....75
[:SOURce<hw>]:BB:OFDM:FILTer:ULENgth?....75
[:SOURce<hw>]:BB:OFDM:FILTer:USELection....75
[:SOURce<hw>]:BB:OFDM:FILTer:WINDowing....75
[:SOURce<hw>]:BB:OFDM:FOFDm:NSUBand....76
[:SOURce<hw>]:BB:OFDM:GFDM:DBSYmbols....76
[:SOURce<hw>]:BB:OFDM:LGUard?....72
[:SOURce<hw>]:BB:OFDM:MODPreset....67
[:SOURce<hw>]:BB:OFDM:MODulation....67
[:SOURce<hw>]:BB:OFDM:NALLoc....82
[:SOURce<hw>]:BB:OFDM:NOCCupied....69
[:SOURce<hw>]:BB:OFDM:NSUBcarriers....68
[:SOURce<hw>]:BB:OFDM:OUTPath....67
[:SOURce<hw>]:BB:OFDM:PRESet....66
[:SOURce<hw>]:BB:OFDM:RGUard?....72
[:SOURce<hw>]:BB:OFDM:SAMPling?....71
[:SOURce<hw>]:BB:OFDM:SCSPace....69
[:SOURce<hw>]:BB:OFDM:SEQLength....69
[:SOURce<hw>]:BB:OFDM:SETTing:CATalog....66
[:SOURce<hw>]:BB:OFDM:SETTing:DEL....67
[:SOURce<hw>]:BB:OFDM:SETTing:LOAD....66
[:SOURce<hw>]:BB:OFDM:SETTing:STORe....66
[:SOURce<hw>]:BB:OFDM:SRATe:VARiation....68
[:SOURce<hw>]:BB:OFDM:STATe....65
[:SOURce<hw>]:BB:OFDM:SUBCarriers?....76
[:SOURce<hw>]:BB:OFDM:TRIGger:ARM:EXECute....98
[:SOURce<hw>]:BB:OFDM:TRIGger:DELay:UNIT....98
[:SOURce<hw>]:BB:OFDM:TRIGger:EXECute....97
[:SOURce<hw>]:BB:OFDM:TRIGger:EXTernal:RDELay?....99
[:SOURce<hw>]:BB:OFDM:TRIGger:EXTernal:SYNChronize:OUTPut....98
[:SOURce<hw>]:BB:OFDM:TRIGger:EXTernal:TDELay....99
[:SOURce<hw>]:BB:OFDM:TRIGger:OUTPut<ch>:DELay....100
[:SOURce<hw>]:BB:OFDM:TRIGger:OUTPut<ch>:FOFFset....100
[:SOURce<hw>]:BB:OFDM:TRIGger:OUTPut<ch>:MODE....100
[:SOURce<hw>]:BB:OFDM:TRIGger:OUTPut<ch>:ROFFset....100
[:SOURce<hw>]:BB:OFDM:TRIGger:RMODe?....95
[:SOURce<hw>]:BB:OFDM:TRIGger:SLENgth....97
[:SOURce<hw>]:BB:OFDM:TRIGger:SLUNit....97
[:SOURce<hw>]:BB:OFDM:TRIGger:SOURce....95
[:SOURce<hw>]:BB:OFDM:TRIGger:TIME:DATE....96
[:SOURce<hw>]:BB:OFDM:TRIGger:TIME:TIME....96
[:SOURce<hw>]:BB:OFDM:TRIGger:TIME[:STATe]....97
[:SOURce<hw>]:BB:OFDM:TRIGger[:EXTernal]:DELay....98
[:SOURce<hw>]:BB:OFDM:TRIGger[:EXTernal]:INHibit....99
[:SOURce<hw>]:BB:OFDM:UFMC:NSUBand....77
[:SOURce<hw>]:BB:OFDM:UFMC:PREequal....77
[:SOURce<hw>]:BB:OFDM:USER<ch0>:DATA....77
[:SOURce<hw>]:BB:OFDM:USER<ch0>:LIST....77
[:SOURce<hw>]:BB:OFDM:USER<ch0>:PATTern....78

[:SOURce<hw>]:BB:OFDM:USER<ch0>:PWR....................78
[:SOURce<hw>]:BB:OFDM:WAVeform:CREate....................67
[:SOURce<hw>]:BB:OFDM[:TRIGger]:SEQuence....................95

Index

Symbols

*.dat file
    Filter ... 19
    I/Q data ... 24
*.iqw file ... 24

A

Allocation
    Boost ... 46
    Conflict ... 48
    Constellation ... 44
    Content type ... 47
    Data source ... 46
    Modulation order ... 45, 53
    Number ... 44
    Physical bits ... 45
    Power offset ... 46
    Split pattern ... 48
    State ... 48
    Subcarrier number ... 45
    Subcarrier offset ... 45
    Symbol number ... 45
    Symbol offset ... 45
Allocation number ... 44
Application cards ... 10
Application notes ... 10
Arm ... 58
Armed_Auto ... 56
Armed_Retrigger ... 56
Attenuation
    Side-lobe attenuation ... 38
    Stopband ... 38
Auto ... 56

B

Bandwidth
    Occupied ... 36
Brochures ... 9

C

Catalog
    User filter ... 39
Clock
    Source ... 62
Codebook ... 50
Codebook size M ... 51
Constellation points
    Imaginary part ... 53
    Magnitude ... 53
    Mapping coordinates ... 53
    Phase ... 53
    Real part ... 53
Conventions
    SCPI commands ... 64
Custom I/Q data
    File format ... 24
Cyclic prefix, CP
    As in LTE ... 33
    Calculation principle ... 32
    Dynamic ... 33
    Enable ... 32
    Enable CP pattern ... 33, 34
    Length ... 32
Cyclic suffix length ... 35

D

Data block size ... 41
Data sheets ... 9
DC mode ... 35
Default settings
    OFDM Signal Generation ... 28
Delay
    Marker ... 61
    Trigger ... 60
Delete
    User filter ... 39
DFT-S state ... 35
Documentation overview ... 8
Dolph-Chebishev window
    Length ... 38
    Shaping ... 38
    Side-lobe attenuation ... 38

E

Export OFDM settings for R&S VSE-K96 ... 29
External trigger ... 59
External trigger delay ... 60

F

f-OFDM
    Filter parameters ... 38
Factor K ... 41
FBMC types
    CMT, FMT, SMT ... 15
FFT size ... 31
Filter
    Cut transient response ... 39
    Dolph-Chebishev ... 37
    f-OFDM ... 38
    GFDM ... 37
    Length ... 38
    Side-lobe attenuation ... 38
    UFMC ... 37
    Windowing method, f-OFDM ... 38
Filter length
    FBMC ... 41
Filter Pre-equalization
    Activate ... 40
First symbol
    Time plan ... 54

G

Generate
    Waveform file ... 28
Getting started ... 8

H

Help ... 8

I

I/Q files
*.dat file ... 24
*.iqw file ... 24
Installation ... 7
Instrument help ... 8
Instrument security procedures ... 9

L

Layer
Power offset ... 51
State ... 51
Layer mapping
Settings ... 51
User ... 51
Left guard
Number of subcarriers ... 36
Load
User filter ... 39

M

Marker
Offset, fall ... 61
Offset, rise ... 61
Marker Delay ... 61
Modulation type ... 29

N

Number
Left guard subcarriers ... 36
Right guard subcarriers ... 36
Number of layers J ... 51

O

OFDM
Settings file automatically created ... 29
Open source acknowledgment (OSA) ... 10
OQAM
Principle ... 15

P

Pilot
Signal analyzer ... 47
PN9
Preamble ... 47
Preamble symbols
Number ... 47

R

Raised cosine filter
See Cosine filter ... 37
Release notes ... 10
Resource blocks
Number ... 40
Retrigger ... 56
Right guard
Number of subcarriers ... 36
Roll-off
See rolloff ... 38
Rolloff factor
GFDM ... 38
Root raised cosine filter
See Root Cosine ... 37
RRC filter
See Root Cosine filter ... 37

S

Safety instructions ... 9
Sampling rate ... 35
Save/Recall
OFDM Signal Generation ... 28
Script
Generate user filter ... 19
Security procedures ... 9
Sequence length ... 32
Service manual ... 9
Set to default
5G candidates ... 28
Settings file
Analysis with R&S VSE-K96 ... 29
Signal duration unit ... 57
Signal generation status ... 57
Single ... 56
Soft truncation
Length ... 38
Windowing method ... 38
Soft truncation window
Shaping ... 38
Split pattern
SCS size ... 49
SCS step ... 49
State ... 49
Symbol size ... 49
Symbol step ... 49
Spreading factor K ... 51
Standard settings
OFDM Signal Generation ... 28
State
OFDM Signal Generation ... 28
Subband
Filter Pre-equalization ... 40
Subbands
Number ... 40
Subcarriers
Bandwidth ... 32
Number of active ... 31
Number of available ... 31
Occupied ... 31
Spacing ... 32
Subchannel
Number ... 40
Superimposed symbols
Factor K ... 41
Symbols
Time plan ... 55
Synchronization
Signal analyzer ... 47

T

Time plan
Open new window ... 55
Time-based trigger
Date ... 57
State ... 57
Time ... 57

Trigger
Synchronize output 58
Trigger delay 60
Actual 60
Expressed in time 59
Resulting 60
Unit 59
Trigger mode 56
Trigger signal duration 57
Trigger source 58

U

UFMC
Filter parameters 38
User
Boost 43
Data source 42
How many 42
Power offset 43
User filter
Create file 19
File format 19
Script 19
User manual 8
User to layer mapping 51

V

Videos 10

W

Waveform file
Create 28
White papers 10
Windowing method
Hamming 38
Hanning 38

Z

Zadoff-Chu
Cyclic shift 52
Sequence length 52
Settings 52, 53